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BALTIMORE CITY WATER DEPARTMENT MEETS EMERGENCY DURING DROUGHT OF JUNE, 1925[1]

BY V. BERNARD SIEMS[2]

Notwithstanding the fact that 20 billion gallons of water were impounded behind our dam at Loch Raven (Gunpowder River) Maryland, from which the City draws its water supply through a tunnel capable of delivering 240 million gallons per day; notwithstanding a filtration plant capacity of 128 million gallons, plus 15 per cent overload and an average daily consumption which did not exceed 122 million gallons for the entire City, the service was seriously hampered and the public in certain sections inconvenienced by inadequate pressure during the drought of the recent season.

The month of June, 1925, was marked by a period of extreme drought and excessively high temperatures, continued for such a record-breaking length of time that the local branch of the United States Weather Bureau stated in a review of the conditions that "it was unlikely another such month would be experienced in Baltimore in a century." From June 1 to June 22, the mean temperature was almost 8 degrees above normal and on thirteen days during this period the maximum temperatures were 90 degrees or more. The last week in May and the first three weeks in June had a total rainfall of only 0.27 inch. This combination of high temperatures

[1] Presented before the New York Section meeting, September 26, 1925.
[2] Water Engineer, Baltimore, Md.

and prolonged dry weather was an ideal one for imposing the maximum possible demand upon a water supply system.

The results of these conditions were immediately reflected in the water consumption, particularly in the closely populated suburban sections lying in the northern and northwestern portions of the City. Much of this territory was included in that annexed to the City in 1918, and was formerly supplied by private water companies whose distribution systems had already grown inadequate to meet the demands for domestic consumption. As this section was most suitable for suburban development its growth was very rapid, but had been anticipated by the Department in the construction of an additional 20 million gallon 3rd Service Zone Reservoir at Pikesville and in the rehabilitation of the distribution systems of the private water companies, and the construction of additional feeder mains.

However, all of this work has not yet been completed and, moreover, large additional areas have been added to the distribution system through the establishment of the Baltimore County Metropolitan District, so that, while the Department would have been able ordinarily to have rendered satisfactory service during the summer months, the extreme weather experienced this year brought about a condition which rendered the water service difficult to maintain.

The increase in the water consumption of the districts mentioned was not of serious proportions when viewed on a twenty-four hour basis, being approximately twenty per cent for the Eastern 3rd Service Zone and twenty-five per cent for the Western 3rd Service Zone, but the peak demand that these two districts created in the early evening hours taxed our pumping equipment to its limits and the distributing facilities far beyond their capacities. In the northwestern district, the Western 3rd Service Zone, between 7:30 and 8:30 p.m. the demand for water was often more than 300 per cent of the normal average consumption, and the peak demands in the Eastern 3rd Service Zone were not much less than this figure. Under these conditions, it was not surprising that a considerable portion of the territories using this excessive quantity of water suffered from a lack of adequate pressure at the time of maximum draft, although I am happy to be able to state that no area was completely out of water at any time.

For two months previous to June 1, 1925, the Pikesville Reser-

voir, on which the Western 3rd Service Zone is balanced, was out of service undergoing repairs and it was just starting to be filled when the hot spell unexpectedly came upon us. The first five days of June, with an average maximum temperature of 96 degrees, were sufficient to deplete the reserve that had been accumulated and for the remainder of the period of maximum consumption, the water that was available from this source was only that which we were able to pump into the reservoir in excess of the consumption during the early morning and forenoon hours. In the Eastern 3rd Service Zone part of the system is balanced on a standpipe which has long since been outgrown by the consumption requirements of the district it serves, so this service was no better situated with reference to a reserve than was the Western 3rd Service Zone.

Both the Western and Eastern 3rd Service districts are normally supplied by the Druid Pumping Station, which takes suction from the Pimlico Reservoir at which the station is located.

This reservoir, which was constructed about 1880, is of about 25± million gallons capacity and at that time was used to furnish the 3rd Service Zone to the then small area within the limits of the 1888 Boundary Line needing it. With the gradual increase of consumers in the Western 2nd Service this lake became inadequate and Lake Ashburton, or the Western 2nd Service Reservoir, was constructed as the main supply for the zone, leaving Pimlico Reservoir to serve merely as suction for the pumps at Druid Pumping Station, supplying both Eastern and Western 3rd Service Zones.

The draw on Pimlico Reservoir caused by the excessive pumping demands was greater than the carrying capacity of the 30-inch supply main to the reservoir, resulting in the reservoir water level being drawn down so low as to necessitate throttling the discharge of the Western 3rd Service pumps to the point where the pumpage was no greater than the quantity of water flowing into the reservoir.

Apparently only 8 or 9 million gallons a day could be forced into Lake Pimlico; even with Mt. Royal or Western 2nd Service Pumping Station working at a 30 million rate it steadily lost water.

This limitation was a serious handicap to the pumpage, as we were not able to operate these pumps to their capacity, and in order to alleviate this condition changes were made in the distribution system to throttle the flow to Ashburton, or Western 2nd Service Zone Reservoir, and thus force more water into Pimlico Reservoir. In addition a 16-inch main into Pimlico, which had

been shut off from this reservoir for a number of years, was placed back in service. These manipulations improved conditions somewhat, but there was still a deficiency in the flow to Pimlico Reservoir, as is shown by the fact that the maximum permissible quantity drawn from the reservoir in any one day during the period under discussion was 11.27 million gallons, whereas the combined available capacity of the Eastern and Western 3rd Service Pumps is 15 million gallons daily. The average daily pumpage for both services from the Pimlico Reservoir for this period—June 1 to June 21, inclusive—was 8.8 million gallons, which is an index of the extent to which the insufficiency of water in the Pimlico Reservoir handicapped the operation of the pumping units. (In determining the maximum available capacity noted above—15 million gallons daily—this is based upon the capacity of the new Western 3rd Service Pumps, 10.5 million gallons daily, and the assumption that we use the old Western 3rd Service Pumps to discharge into the Eastern 3rd Service, with a maximum output of 4.5 million gallons daily.) In this connection it should be noted that although we have a maximum of 4.5 million gallons daily available for the Eastern 3rd Service Zone, the lack of a reservoir in this district limits the amount of water that can be pumped during the day and made it practically necessary that the peak demand be met by direct pumpage, as the storage in the standpipe did not last more than thirty to forty-five minutes when the peak came on.

To increase the flow to the Eastern 3rd Service Zone during the maximum draft, a division valve in the Druid or 3rd Service Pumping Station was operated to permit water to flow from the Western 3rd Service; this imposed a heavy draw on the Western Service and to compensate for this as far as possible water was supplied to the Western 3rd Service from an independent source, via (Patapsco River) Avalon, Catonsville Reservoir, 4th Service Zone Standpipe (Ingleside) and Hillsdale Pumping Stations. The flow from this source amounted to approximately 1.14 million gallons daily and it was possible to use it only ten days between June 3 and June 12, as the filter beds at the Avalon Filtration Plant limited their capacity to such an extent as to make it impossible to maintain the water level in the Catonsville 3rd Service Zone Reservoir above the point where the pump suction would be impaired.

The changes in the Distribution System to augment the flow into Pimlico Reservoir, the use of Western 3rd Service to boost part of

the Eastern 3rd Service Zone supply, and the introduction of the Avalon-Catonsville-Hillsdale supply to increase the flow into the Western 3rd Service Zone represented the maximum effort that could be made, with the available facilities, to meet the conditions confronting us, and the service which a large number of consumers were receiving, particularly in part of the Eastern 3rd Service Zone district, was far from satisfactory. Accordingly, it was decided on June 5 to install a temporary pumping station to supply the Eastern 3rd Service Zone from a supply independent of the Ashburton-Pimlico Reservoir System, using a 3 million gallon centrifugal pump which was suitable for the service proposed. This pump was the only equipment we had which could be used, making it necessary for us to obtain a motor and controller, arrange the pump for belt drive, and do all other work required to get the station in operation. Suction was taken from an Eastern 2nd Service Zone 36-inch supply main, the discharge being into a 16-inch Eastern 3rd Service Zone supply main, the two water main connections being within approximately two hundred feet of each other.

The pump was first turned over on June 9, four days after work started, but, due to trouble with the belt drive, was not put into actual service until June 12, one week after the ground was broken. The delivery from this source was at the rate of about 2.90 million gallons daily and the pump was operated daily continuously from early morning until about 11:00 p.m., the deficiency in the service being made up when necessary by operating at Druid Pumping Station.

The operation of the temporary station immediately relieved conditions in the Eastern 3rd Service Zone, and with the removal of the load from the Druid 3rd Service Pumping Station, which the temporary station allowed, a betterment in the Western 3rd Service was soon noticed. By putting into the Western 3rd Service the water which had been going into the Eastern 3rd Service, we were enabled to gradually build up a reserve in Pikesville 3rd Service Zone Reservoir, and at the same time allow the Pimlico Reservoir to return to normal, so that by the latter part of June all districts were being adequately supplied.

During the hot spell the levels in all the reservoirs of the Department were very much lowered, Ashburton or Western 3rd Service Reservoir being drawn down 10 feet, but not enough to cause any uneasiness, with the exception of Towson Reservoir, supplying the

extreme Eastern 3rd Service Zone and for suction of the Pumping Station for Eastern 4th Service Zone. Here the level became so low as to threaten the operation of the automatic pumping station located at the reservoir, and this required us to augment the service by the operation of the Mt. Washington Pumping Station (for emergency use only). By this means, the conditions at Towson were soon restored to normal, and this brought all of our difficulties due to the prolonged hot spell to a close.

During this emergency the engineers and workmen remained on their jobs voluntarily for long hours and without complaint, manifesting only interest in relieving the situation and indeed the excellent coördination of their work was responsible for the success with which the condition was handled.

Our analyses of the condition indicated that it was brought about by the excessive use of lawn sprinklers and hose connections for wetting down the pavements and sidewalks, and the increase in consumption was observed almost entirely in those suburban sections where the water supply services remain unmetered.

Inspectors of the Department were sent into these zones to urge the conservation of water and the Police Department as well cooperated in discouraging waste, for sprinklers were found running twenty-four hours per day unattended. Notices were inserted in the newspapers restricting, by order of the Water Board, the use of hose connections during the mid portion of the day or that portion of the day in which the normal peaks are experienced and finally prohibiting their use altogether until the condition improved.

While it might be said that on the whole the people coöperated, considerable unfavorable comment resulted because of the inability of the people to understand, as was reasonable, why certain sections of the City should experience slack water supply and be subject to restrictions in its use, while other sections of the City remained unrestricted, and while there was 20 billion gallons of water available behind the Gunpowder Impounding Reservoir dam at Loch Raven.

As this belief of the people could not be speedily altered and as Baltimore is practically an unmetered city (16 per cent metered) we met the emergency in the only manner we thought practicable, that is, after trying educational and persuasive methods without success, by providing additional pumping facilities and letting them have all the water they wanted.

DISCUSSION

R. J. NEWSOM[3]: Last winter in January, the City of Lynn had to meet a situation similar to that described by Mr. Siems; namely, to make a main designed as a distribution main in a certain district, act as a force main carrying a great deal of water and much more than was formerly supposed to go through it.

The city of Peabody, immediately adjacent to the City of Lynn has been using water in excess of the safety sources of supply for some years and gotten away with it until the last two or three years which were very dry. In the fall of 1924 they got down to the point where they had about two months' supply and then the rains fortunately came and they got along for another year. Last fall, however, the drought continued and in January they had reached the place where they had only about one month's supply left and it was necessary to get water immediately from some source.

The only point at which the distribution of the City of Lynn was connected with that of Peabody was in the sparsely settled district of each city, and the main on the Peabody side was only 6 inches so there was no opportunity of getting them any quantity of water. Peabody has not more than 25,000 people, but, due to the presence of several tanneries, they use about three and a half million gallons of water a day. They wanted to get that amount from the City of Lynn.

The pond from which the supply for the City of Peabody is directly taken, is near a thinly settled section of the City of Lynn which was fed by a line of pipe 4000 feet long, 2000 feet of it 10 inches and the other 2000 feet 8 inches.

It was thought that there was a possibility of filling into this pond of theirs from our distribution system, if we could get enough water through that line to be of any assistance. The pressure at the point nearest their pond was only about 32 pounds, the district being very high. And while it was fed by the low pressure system of the city, it was so near the dividing point that there was no possibility of getting any great quantity of water to that main.

At the point where the 4000 feet of pipe began, there were two 10-inch lines coming together. In order to deliver two and one-quarter million gallons of water which we thought we could spare daily, it would be necessary to raise that 40 pounds pressure to 100

[3]Water Commissioner, Lynn, Mass.

pounds. We were anxious to do the work as economically as possible and neither the City of Lynn nor Peabody had a pump of proper capacity. We looked around and found, through the kindness of one of the consulting engineering firms in Boston that there was for sale in the City of Waterville, Me., a pump and motor that exactly fitted the conditions—a pump designed to deliver two and one-half million gallons of water against a 100-foot head.

With less than two months' supply of water in the Peabody system it was necessary to work rapidly and while we did not do the work in a week, we felt that getting the thing in operation in three weeks was fairly rapid.

The pump was shipped from Maine and while it was on its way we made a tapping on each side of the gate which controlled this 4000 feet of main pipe, carried the 28-inch connection over to the side of the street, made a temporary arrangement for the use of some land, dug a pit, concreted it to a depth of 5 feet and had things all ready to set the pump in place when it arrived. The Electric Company in the city fortunately had a 120-foot line in the vicinity and that was sent over. A small wooden structure was built and in about three weeks' time we had the thing in operation.

We found, however, after we got it in operation we had a couple of problems yet to meet which we had not anticipated. In the first place the entire pressure was practically used up in delivering this amount of water to the end of the pipe. Of course, an electrically driven pump has sometimes proved to stop at a rather inconvenient time, due to the interruption in the electric service. When that happened with only 40 pounds pressure at the point where the pump was operating, with an opening 4000 feet away, there was no pressure to deliver water to the houses at the end of that district.

We also found that, even when the pump was operating, there was such an enormous amount of noise in the main due to the rush of water through the 8-inch pipe, and the noise made by the motor at the end of it, that we got serious complaints from the people who were living near that end of the main. By investigating we found that at the point where the 8-inch pipe began, in other words about halfway between the pump and the end of the line, we had approximately 50 pounds pressure when the pump was operating and if the pump shut down we had 20 pounds pressure. To get around both of our troubles, we tapped in a 2-inch line at that point and we

carried it parallel with the 8-inch pipe for a distance of 2000 feet and buried it under the ground. The noise at the point where the 2-inch pipe was tapped off was negligible and of course the pressure of 20 pounds was sufficient to deliver water through a 2-inch pipe for a short length of time until we could get the pump operating without causing any trouble from pulled in water or anything of that kind.

We found, of course, that burying the pipe we wanted to a depth of 6 inches was not going to keep it from freezing in the middle of the night and we realized also that the water was going to be warm during the summer, so we made a small three-quarter connection on the end of the 2-inch line and carried it over into the meter box, put a small meter on that and let that line also run into the pond alongside of the big line. This served to keep the water from freezing in the winter and to keep it cool in the summer.

There were some incidental results from taking on this particular job. It occurred as those things always do, at a time when our own system was drained down. We have pretty good sources of supply and pretty good storage, but while we ordinarily take water into the system in the early fall, it was then the first of February and we were just then beginning to fill. There had not been any water in until that time so it was necessary for us to use water from a source of supply that we put in merely as a reserve in order to fill our reservoir up in the three months that remained. We ordinarily had six months in which to do it. We also found that the taking on of 33⅓ per cent increase in our load made it impossible for our reserve pump in the pumping station to care properly for the total load and we had only one pumping station. We ordered, therefore, an entirely new set of duplicate parts for the centrifugal pump, duplicating any part of the pump so that we could make a shift in a few hours in case of trouble with that pump.

THE PREVALENCE OF SIMPLE GOITER AND ITS RELATION TO IODIN CONTENT OF WATER AND FOODS[1]

By J. F. McClendon[2]

Iodin was discovered in 1811 and in 1820 was shown to have curative effects on large goiters. Since it did not cause a reduction of the connective tissue and blood vessels in the goiters, complete reduction was not effected from the standpoint of beauty, so its virtues did not become universally known.

Without the knowledge of the element, iodin, iodin-containing substances had been used by the Chinese five thousand years ago and continued to be used in various countries up to the time when it was shown that their virtue lay in the iodin content.

Chatin in 1850–1853 showed that goiter is due to iodin deficiency and advocated the use of iodin as a prophylactic procedure, but did not succeed in convincing the public of this, so it was not until Kimball and Marine, about ten years ago, started experiments on school children of Akron, Ohio, that the prophylactic procedure was adopted. It was immediately taken up by the Swiss and now in some cantons of Switzerland the government sells salt to which iodin has been added, which they call "Vollsalz." In some other cantons they feed school children at intervals with tablets containing iodin. The State of Michigan is now taking up the iodized salt plan. The cities of Rochester, New York and Sault Ste Marie, Mich., are adding sodium iodide to their city water supplies. Tincture of iodin is advocated by Major A. P. Hitchens of the Medical Corps of the United States Army for sterilizing water where safe drinking water is not at hand. The method is to add one drop of tincture of iodin to a quart of water and wait thirty minutes when all the ordinary harmful bacteria are killed. This amount of iodin is too slight to taste, yet ample to protect from goiter, even if such water is drunk only occasionally.

[1] Presented before the Minnesota Section meeting, November, 1924.

[2] From the Laboratory of Physiologic Chemistry, University of Minnesota, Minneapolis, Minn.

It was shown by McClendon and Hathaway that if we draw a line across the United States begining in northern California and passing south of Nevada, Utah and a part of Colorado, bending North to South Dakota, passing south of Iowa, cutting Illinois in two, passing south of Kentucky, and then going northeast parallel to the Atlantic Coast, the region north of this is highly goiterous and the region south of this is almost free from goiter. The region on the north side contains very little iodin in the water and the region south of this line contains much more iodin although still a small quantity. The line of division is of about one part of iodin per billion parts of water, but this is mainly of surface waters because some deep waters and those contaminated with considerable sewage are higher in iodin than the surface waters.

E. F. Eldridge of the Michigan Department of Health has made an iodin survey of Michigan, but his method of analysis was not as delicate as ours and he was not able to detect the iodin in most of the surface waters. He found rather large amounts of iodin in the region of the State in which salt is mined by pumping down water and evaporating the brine. The strip went from Midland near Saginaw Bay to Lake St. Clair. Furthermore the whole southern part of the State contained some underground waters which contained about one part of iodin per billion of water. He did not find any iodin in the northern half of the State where goiter is more prevalent.

Recently, Hathaway has shown that in the State of Utah there is an inverse relation between the iodin in the water and the goiter in the school children; Alpine Canyon and Santaquin show low iodin and a high rate of goiter, whereas Lakeview and Goshen show much more iodin and much lower rate of goiter.

From the iodin balance of the human body, McClendon and Hathaway have shown that about one part of iodin in one hundred million parts of water is perfectly safe to drink exclusively and is about sufficient to prevent goiter even though the diet was extremely goitrous. Some persons drinking goitrous water are protected from goiter by eating foods high in iodin. The article of food, par excellence, for obtaining the iodin ration, is butter. Leafy vegetables and some fruits, particularly tropical or semi-tropical fruits, as well as many sea foods, are also high in iodin.

THE SPACING OF FIRE HYDRANTS[1]

By F. H. King[2]

A water company is interested in the spacing of fire hydrants because hydrant rental is usually one of the principal sources of its revenue. The municipality is interested because upon the spacing depends adequacy of the fire protection and also because of the rating of the town for insurance purposes. Fire underwriters are interested because they know that proper protection means smaller losses from fire and lower rates to the insured. The public generally is interested, but leaves to others the job of looking after the details.

Several years ago Leonard Metcalf, W. C. Hawley and others made exhaustive studies of the investment in water works equipment required to furnish fire protection and the portion of expense of operation due to fire protection requirement and it was shown that the revenue derived from this source was not sufficient to pay interest and expense. Inasmuch as the cost of water works construction has doubled in ten years and the cost of operation has also doubled in the same period, no effort will be made here to show how far short revenue from fire protection now fails to carry its burden of cost; for this revenue, always deficient, has not increased materially, if at all, during the past ten years.

Before the war an average extension would cost say $6600.00 per mile. The same extension today would cost $13,200.00 and ten hydrants at $38.00 per annum each would yield a little under 6 per cent prewar and less than 3 per cent today on the extension alone. The balance of the interest that must be earned on the extension, also interest on feeder mains, meters, supply works and all operating expense and taxes and depreciation must be earned by sale of water to consumers, and it is our experience that in many cases where extensions are ordered there are few or no consumers.

The above shows where the interest of a water company lies in hydrant spacing.

[1] Presented before the Iowa Section meeting, December 4, 1925.

[2] Davenport Water Company, Davenport, Iowa.

Where hydrant spacing is wide the fire department is handicapped because it must carry much more hose to lay the same number of streams on a fire. It takes more time to get the streams in action after the arrival of the department and the effective pressure at the nozzle is much less, due to long lines, consequently the quantity of water available to quench the fire is also less.

All insurance rates are based on the rating of the town, which rating takes into account the hydrant spacing.

Taxes are now so burdensome that no fault can be found with the proposal of the city to set fewer fire hydrants, in order to save hydrant rental, but if the saving is only imaginary and the amount saved is paid in fire losses and extra premiums it would be better to install more hydrants.

The spacing of fire hydrants in Davenport is fairly good and is equal to about ten hydrants per mile of main pipe or one hydrant per 528 feet of pipe. There are 122 miles of pipe and 1211 hydrants. In ten years 36 miles of pipe have been laid and 387 hydrants set which is an average of 10.7 hydrants per mile of pipe laid. The number of hydrants set per mile of pipe has not been less than nine in the past ten years and was 15 in the year 1916, due to the recommendation of the National Board of Fire Underwriters that additional hydrants be located in the principal mercantile district.

Our blocks, are, generally speaking, about 400 feet square. If water mains are laid in one direction only and one hydrant is placed at each street intersection there would be 13.2 hydrants per mile of pipe. If, on the other hand, mains are also laid on all cross streets completing a gridiron, with blocks 400 feet there would be 6.6 hydrants per mile of pipe. Practically the proper number lies about half way between 6.6 and 13.2 so that from ten to twelve hydrants per mile of pipe may well be set in outlying territory.

In their last report on fire protection in Davenport, the National Board stated that in the principal mercantile district the area served per hydrant was 44,000 square feet and in the total area outside the principal mercantile district there was one hydrant to each 190,000 square feet of territory. This report further states that the spacing is good in the principal mercantile district, in most high value districts and in residential districts where the blocks are small; the spacing is wide in some sections where blocks are long or the gridiron incomplete.

The recommendation of the National Board is that there shall be one hydrant at each intersection in residential districts except where

blocks are long and, in such cases, additional hydrants should be placed.

During the past year or two the tendency has been toward wider spacing—in some cases two or three blocks between hydrants—on the score of economy.

Hydrants are operated by men who are not employees of the Fire Department or the Water Department and we sometimes find them broken. One fire that spreads may easily cost more than all the hydrant rental for several years. One hydrant at each street intersection does not seem to be too many and sometimes it is not enough for first class protection.

ZEOLITE SOFTENING PLANT OF THE OHIO VALLEY WATER COMPANY[1]

By F. B. Beech[2]

On November 15, 1922, the Ohio Valley Water Company installed a small zeolite plant to serve a two-fold purpose—first for boiler feed water and second for experimental purposes. This plant paid for itself in the first ten months by fuel saving and boiler maintenance.

After 404 days of constant use the Water Company made careful physical and chemical tests of the material to determine its characteristics as well as its durability. It was found from analyses that there was so little difference between new material and that which had been used in the boiler-house filter for over twenty months, that they might be easily due to sampling. The only important change was an increase in manganese from 0 to 0.28 per cent. This was expected after so long contact with a water containing manganese. It is remarkable that there had been so little accumulation.

Microscopical examination of the used material showed it to be free from coating and to consist of partly rounded brownish grains.

The raw material which is used in the zeolite process is called "Glauconite" by the geologists. The word "Glauconite" is derived from the Greek word "glaukos" meaning bluish gray or greenish gray and the raw glauconite fits this descriptive name very well. The common name for glauconite is "Greensand" and it is this name that the Government bulletins use. At the pits where it is dug it is usually called "marl" or more properly "potash marl."

This material of many names is extensively distributed over the face of the earth but the largest and purest deposits known are in New Jersey. They here form a bed stretching some 100 miles from Sandy Hook on the north to Delaware Bay on the south and are some 10 miles in breadth. Continuing south they cross Delaware, Maryland and Virginia, but the deposits in these other states are not as

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Superintendent, Ohio Valley Water Company, McKees Rock, Pa.

pure as the New Jersey beds. The thickness of the beds vary from a few feet up to over thirty feet and the supply may popularly be said to be inexhaustible.

These greensand beds crop out at the surface in many places and the amount of overburden that has to be stripped off is usually from four to ten feet and it is not considered very profitable to work beds that are covered with much more overburden than this. The methods, of mining, therefore, are all open pit workings. The overburden is cleared off by scoops or steam shovels and the marl is gotten out by scoops or steam shovel when it is above the water table, and usually by a clam shell bucket when below the water table. The marl when wet is black in color and when dug and dried is grayish green. The clay and fines are what give it its grayish color and when these are washed off the real green color of the material appears. The marl as it accrues is fairly firm and can be walked on in safety but when it has once been stirred up in the water it is as treacherous as quicksand.

The washed glauconite consist of granules of varying size and varying shades of color. The size of these granules runs from less than $\frac{1}{100}$ inch to about $\frac{1}{16}$ inch in diameter. The bulk of the material will pass through a screen running 20 meshes to the inch and will be retained on an 80 mesh screen. The color of the dry grains varies from light green to dark green, sometimes distinctly bluish in tint and the mineral always contains some grains of varying shades of brown. These grains when examined under a magnifying glass appear irregularly rounded and polished as if they had been subject to wave action. Each grain is seen to be made up of smaller particles which are cemented together by a much lighter, almost white material.

Some of the other substances occurring in greensand are limestone, quartz, gypsum and iron pyrites. This last named material is generally called "fool's gold" on account of its golden appearance and the fact that many have been fooled by it. An examination under the microscope will reveal all these substances and will often reveal very small fishes' teeth, many of which are only about $\frac{1}{16}$ inch in length.

The presence of fossils and shell casts points to the fact that glauconite is a marine formation. This has been substantiated by deep sea dredgings made by the "Challenger," by which samples of glauconite in the process of formation on the sea bottom were obtained. In

fact, the shape of many of the particles indicates that they are internal casts of minute shells. The formation of the mineral from iron bearing clays, organic matter and potash, either from the sea water or other minerals is indicated. Glauconite is essentially a hydrous silicate of iron, aluminum and potash but it always contains other substances and analyses of glauconite from different places vary considerably. The following analysis of glauconite taken from Bulletin No. 660 of the United States Geological Survey shows its approximate composition:

	per cent
Silica	50.0
Ferrous oxide	4.0
Ferric oxide	19.0
Alumina	7.5
Magnesia	3.0
Potash	7.5
Water	8.5
Soda and lime	0.5
	100.0

Greensand has also been ground very fine and used as a pigment for making green paint, however, the one use of greensand in which we are most interested is the use of it in water softening, and this depends on a most curious property that this interesting material possesses. This property is called base-exchange, and the substances which possess it are called base-exchange silicates, or popularly zeolites. The name zeolite means "boiling stone" and zeolites are so called because when heated they swell up and give off steam due to chemically combined water being driven off by the heat. When soluble potash salts such as exist in fertilizers are strewn on a field they dissolve in the rain which falls on them and we should suppose that they would be washed out of the ground very readily. Such, however, is not the case. It is found instead that certain substances in the soil combine with the potash and hold on to it so that it is not washed away. These substances are zeolites and the plants are able to obtain their potash from the potash containing zeolites.

Experimental work on these zeolites revealed the secret, and that was that the zeolites were able to exchange bases such as lime, or magnesium, or barium, or soda, or potash, or ammonium, and that these exchanges could be made by simply bringing the zeolite into

contact with a water solution of a salt containing the particular base which we wished the exchange to be made. In time it was found that other substances than zeolites (boiling stones) also possessed these base exchanging powers and among these other substances is greensand. Greensand does not swell up when heated and it is more properly classed among such silicates as talc and serpentine, but since it possesses base exchange properties, it also is called a zeolite.

Raw greensand is most thoroughly washed free from mud and clay, it is then stabilized and finally is screened to proper size. In this refining process about 40 to 60 per cent of material is discarded as unfit for use, these discards being clay, mud and mineral either too fine or coarse.

The term "stabilized" refers to a process as changing a material (clean, sound, greensand) from a softer, fairly easily disintegrated substance to a flint-hard, stable, uniform and not easily disintegrated substance.

When hard water is filtered through zeolite the hardness of the water (the lime and magnesia salts) is removed and the resultant water is termed softened water, soft water or zero water. What has happened is that the zeolite has exchanged its sodium for the lime and magnesia of the hard water. If a soft water, for example, a distilled water, is filtered through zeolite nothing at all happens and no soda is given off. If a water containing 10 grains of hardness per gallon is filtered through zeolite, then the mineral takes out the 10 grains of hardness and puts in an equivalent amount of soda. If water containing 20 grains of hardness per gallon is filtered through zeolite then the mineral takes out the 20 grains of hardness and puts in the equivalent amount of soda, but in this case it will be found that only one-half as many gallons of softened water may be obtained from a certain weight of mineral as of the 10-grain water before mentioned, with the same amount of mineral. In other words, zeolite is insoluble and will give up nothing to a distilled water, but when a hard water comes in contact with it the mineral takes the lime and magnesia out of water and into itself and puts back in the water an equivalent amount of soda. This soda is in the form of the salts of the lime and magnesia originally present. The amount of hardness that a pound of mineral can take out of water is fixed and this figure is called the mineral's "exchange capacity." When this "exchange capacity" or simply "capacity" is "exhausted" the mineral is in its "hard" or lime and magnesia

condition and must be brought back to its original sodium condition before it can soften any more hard water. This restoration is called "reconditioning" or "regeneration." Reconditioning is done by filtering a solution of common salt through the "exhausted" bed. The sodium in the salt solution combined with the zeolite and the chlorine in the salt solution unites with the lime and magnesia of the mineral forming extremely soluble salts which are washed down the drain with the excess of common salt. If the salt wash is tasted, the first portion of it tastes very bitter (like Epsom salts)

TABLE 1

Comparative analyses

DETERMINATION	RAW WATER	EFFLUENT AFTER PASSING ZEOLITE SOFTENER, 1000 GALLONS PASSED
	p.p.m.	*p.p.m.*
Odor, cold, 20°C	1 (aromatic)	1 (aromatic)
Odor, hot, 90°C	1 (aromatic)	1 (aromatic)
Turbidity, silica standard	Trace	Trace
Color platinum	2.0	2.0
Oxygen consumed	2.1	0.9
Nitrogen as free ammonia	0.058	0.098
Nitrogen as total alb. ammonia	0.092	0.016
Nitrogen as nitrites	0.400	0.060
Nitrogen as nitrates	0.360	0.300
Chlorine	15.0	18.0
Alkalinity	68.0	71.0
Hardness by soap method	151.4	0
Iron	0.15	0.10
Total residue on evaporation	490.0	300.0
Manganese	1.3	Trace

due to its lime and magnesia salts, and then gradually this disappears and the taste of common salt (due to the excess of it that is always used) takes its place, this fading out as the pure softened water displaces it.

In the design of a zeolite water softening equipment, the uniformity and size of the grains of the mineral is a factor insofar that if the grains of mineral are too small, there will be an increased loss of head with the water passing through the mineral, whereas the mineral too large in diameter will permit the water to pass without having all the hardness removed, and from experience, the

mineral must be so graded to uniform size as will permit a maximum amount of water to pass entirely softened with the minimum amount of head loss.

The ability to exchange almost instantly is a characteristic of zeolite, particularly so in the softer waters, say up to 16 grains hardness, where the limitations are more of a mechanical nature than the exchange rate of 6 gallons per square foot per minute, now in commercial use.

In such cases where the water hardness is about 20 grains, the exchange rate is about 5 gallons per square foot, per minute and under conditions of a 25 grain hardness, the exchange rate would be 4 gallons per square foot per minute.

From these figures, a 9-foot by 22-foot softener would have the capacity to deliver softened water to zero hardness at a maximum rate of 72,000 gallons per hour or about 1,700,000 gallons per twenty-four-hour period, delivering this amount of softened water under proper conditions of installation.

As to salt efficiency; recent developments in the method of salt application have reduced the ½ pound of salt per 1,000 grains of hardness removed, to a figure slightly over ⅓ pound of salt or 1000 grains of hardness (as $CaCO_3$)removed.

This development in salt efficiency is principally due to a method of uniformly applying the salt throughout the entire area of the softener as well as to recent developments in the process of stabilization.

Softening by zeolite being comparatively new, the Water Company found that no attempt had been made heretofore to soften water for public use to the extent they required, i.e., 4 m.g.d., so lengthy studies and experiments were made by competent engineers who determined that there was very little difference in costs between softening by Lime-Soda Process and the zeolite process and recommended the installation of the Zeolite Process, consisting of four 9-foot by 22-foot tanks.

SUMMARY AND CONCLUSION

The new plant will remove manganese and Crenothrix, making the water suitable for laundry and other washing purposes, prevent stains on pumbing fixtures and save the large cost which the cleaning of mains and the replacing of services would require.

Lime-soda will reduce hardness from an average of 190 to 60 p.p.m. The Zeolite process may be used to reduce the hardness to any desired degree down to zero.

The Zeolite process requires little space as compared with Lime-Soda process. In fact the Water Company required little or no additional space, having built the softening house on one-half of the existing surface of a covered concrete detention basin (500,000 gallon capacity) which had been used for years.

The Zeolite process is flexible and certain, requiring no highly trained men to operate.

This plant has been in operation for about a month and while it is too early to give any definite operating report, we do know that it fulfills all expectations to date and can be operated cheaper than expected. Salt being the only requirement it naturally follows that the cost of salt is a large factor in cost of operation. The Water Company has secured a yearly contract for salt at 20 per cent less than the original figures.

GROUND WATER RESOURCES OF ILLINOIS[1]

By G. C. Habermeyer[2]

If you cross the river to East Dubuque or go to the City of Galena which is close by and then travel in any direction across the State of Illinois, you will find that the farther you proceed, the poorer are the ground water resources. The principal water-bearing strata in the state are sandstones of the Cambrian system often referred to as Potsdam sandstone. Sandstones of this system outcrop in the central and western part of Wisconsin, north of a line through Milwaukee as far north as Wisconsin Rapids, to the northeast and northwest of that city, and in Iowa and Minnesota along Mississippi River. The St. Peter sandstone, which is above the Cambrian sandstones, is next in importance. The principal outcrop of this sandstone is in southern Wisconsin. It is exposed in Illinois in an area near Oregon on the Rock River, near Ottawa along Fox and Illinois Rivers, and is exposed or close to the surface in a few other small areas. These strata slope downward to the east and south with one sharp fold, the LaSalle anticline, from near the northwest corner of the state southeastward through LaSalle, as given in detail in publications of the State Geological Survey Division.

Possibly the statement that the farther we travel from East Dubuque or Galena the poorer are the ground water resources, is a little broad, for, to the east throughout much of the northern part of the state, considerable water is available in gravel deposits and in the underlying rock strata, especially the sandstones referred to. As far to the east as Rockford, water obtained from Cambrian sandstones is of as good quality as that at Galena and it is available in large quantity. Farther east, in the northeastern part of the state, waters from these sandstones are more highly mineralized and the sandstones are also probably softer than the same strata in other sections. Conditions are probably worst at Des Plaines. Gray Brothers drilled a well there into Cambrian sandstone and, after

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Engineer, State Water Survey Division, Urbana, Ill.

placing successive casings of smaller size, abandoned the hole at a depth of 1800 feet. A few years ago the village drilled another well and, after reaching almost as great a depth, gave up the effect to secure any considerable flow from these sandstones.

Near Chicago and south of Chicago, near the eastern border of the state, a considerable amount of water is secured from wells into the upper rock stratum in that locality, the Niagaran limestone. Some of these wells in Cook County have very large yield, but the yield of some of the wells in use is very limited.

Proceeding southeastward, or southeastward and southward from Galena, the change in ground water resources is much more marked than it is to the east of Galena. Until Illinois River is reached, nearly all large supplies are from the St. Peter and Cambrian sandstones. As one proceeds, however, he will find the waters more highly mineralized and the increase in mineral content will be sufficient so that, to many, it will be noticeable to the taste. This is especially true if one travels toward a point far downstream on the river, that is, if he stays in the western part of the state. In the central part of the state west of Illinois River, a few cities pump water from Mississippi River and a few pump water from impounding reservoirs on small streams, but a large majority use the rather highly mineralized waters from the St. Peter and Cambrian sandstones. If Illinois River is crossed at LaSalle or upstream from that point some wells into these sandstones will be found a short distance beyond the river. Along the river a few important supplies have been developed from sandstone which lies between the St. Peter and the Cambrian system.

In the central part of the state, east of Illinois River, the ground water supplies are principally from sand and gravel deposits. Water from underlying rock is in most places too highly mineralized for general use. Where the supply from sand and gravel is not sufficient, surface water supplies are developed.

In the southern part of the state, little water is available from sand and gravel and the waters from underlying strata are highly mineralized. Drinking water is secured in many places from comparatively shallow private wells and several of the larger cities have developed public water supplies using filtered river water. Limited supplies of ground water were developed at Marion, Carbondale, and a few other places, from wells into rock. These rock strata do not extend to the northern part of the state. While the waters are highly

mineralized they are comparatively soft. At some places along Mississippi River, especially between East St. Louis and Alton, at some places along Ohio River, and in a few other limited areas along other streams, considerable water of good quality is available from sand and gravel deposits in stream valleys.

Continuing our travel to the southern limits of the state, as we approach Ohio River we come to wells into sand and gravel and wells into rock which yield considerable water of good quality. The supply is not as abundant as in the northern part of the state and our friend, Mr. Roos, pumps water from Ohio River to supply the City of Cairo.

The sources of the public ground-water supplies in the state are given in detail in Bulletin No. 21 of the State Water Survey Division. A part of the data for a few of these supplies will be given in order to give some definite figures in place of the comparative terms which have been used.

At Galena, near the northwestern corner of the state, the city drilled a well a few years ago. It is 8 inches in diameter below a depth of 150 feet. The top is 610 feet above sea level. St. Peter sandstone is at a depth of 140 feet and the flow from this sandstone at the ground surface was one or two gallons a minute. Cambrian sandstone was reached at a depth of 485 feet. At a depth of 1445 feet the flow was 560 gallons a minute. The well was drilled to a depth of 1513 feet and the flow when the well was completed was 560 gallons a minute. The yields were affected somewhat by yields of other wells, especially one city well 130 feet distant. The water has a mineral content of 260 and a total hardness of 255 parts per million.

At Rockford, in the center of the northern tier of counties of the state, many wells have been drilled into Cambrian sandstones. The elevation of the ground surface at some of these wells is about 100 feet higher than the ground surface at the Galena city wells, the depth to St. Peter and Cambrian sandstones is about 100 feet greater, and the wells are drilled about 100 feet deeper, to about the same depth into the Cambrian sandstone. Wells 12 inches in diameter at the bottom, at considerable distance from other wells have yielded around 1400 gallons a minute. Exact data of the lowering of water level are not available, but it was close to 90 feet. The water had a mineral content of 298 and a hardness of 245 parts per million.

The City of North Chicago on the shore of Lake Michigan, near

the northeastern corner of the state, is supplied with water from two wells. The elevation of the tops of the wells is very near the elevation of the tops of the Galena city wells. St. Peter sandstone was reached at a depth of 820 feet and a record of the wells indicates that the Cambrian sandstone is about as far below the St. Peter sandstone as it is at Galena. One well was drilled to a depth of 2269 feet, which is about the same depth into Cambrian sandstone as is penetrated by the wells referred to at Galena and Rockford. This well, when completed, yielded 1200 gallons a minute. A well 1695 feet deep, 10 inches in diameter at the bottom, is located 65 feet distant, and this accounts for a part, probably a small part, of the yield of 1200 gallons a minute from the deeper well. The well 1650 feet deep yielded 1050 gallons a minute with a lowering of the water level of 100 feet. The wells flow when not pumped. The mineral content of the water from the deeper well is 760 and the hardness 425 parts per million.

The City of Galesburg, in the central part of the area west of Illinois River, drilled a well to a depth of 2414 feet. St. Peter sandstone was entered at a depth of about 1090 feet. The well is 10 inches in diameter at the bottom. It yielded 1200 gallons a minute with a lowering of water level of 46 feet. The water has a mineral content of 1033 and a hardness of 250 parts per million. Waters in use from wells into St. Peter sandstone in this section of the state, contain from 1500 to 3000 parts per million of dissolved mineral matter.

In the central part of the state, east of Illinois River, some waters secured from wells into rock have contained more than 50,000 parts per million of dissolved minerals.

The wells into rock which were used by the City of Marion were about 900 feet deep. Some wells would yield 60 gallons a minute when new, but yields of less than 10 gallons a minute were common. The last sample of water analyzed had a mineral content of 865 and a hardness of 16 parts per million.

A well into rock from which the public water supply of Mound City is secured is 634 feet deep. The top is about 320 feet above sea level. When drilled, the water is reported to have raised to 75 feet above the ground surface and the flow was reported to be 85,000 gallons a day. The water level is now just above the ground surface and water is drawn from the well by suction at a rate of 280 gallons a minute. The water has a mineral content of 280 and a hardness of 135 parts per million.

THE MUNICIPAL WATER AND LIGHT PLANT AT ORLANDO, FLORIDA[1]

By W. W. Mathews[2]

Orlando, Florida, "the city beautiful," determined upon municipal ownership of the Water and Light Plant in 1921. The original plants built in the 80's had become inadequate, and due to the phenomenal growth of Orlando during and subsequent to the World War, the utility situation was very acute about 1920. The following facts will be sufficient to illustrate the burden placed on these utilities.

The population of Orlando increased 137 per cent from 1910 to 1920 and most of this growth occurred in the last three years of that decade. The population has doubled between 1920 and the present time as evidenced by the growth in water and electric consumers as well as local census figures. The present population is approximately 20,000.

This great rate of growth imposed severe financial burdens upon the utility management which could not meet them with the franchise and other conditions then prevailing. Municipal ownership or acquisition of the properties by some company of large financial resources seemed the most practicable procedure. The city and company accordingly agreed upon an arbitration proceeding to determine the value of the properties for transfer.

The company selected Cecil F. Elmes, Chicago representative of Sanderson & Porter, the city selected L. R. Howson of Alvord, Burdick and Howson of Chicago, and Dabney H. Maury of Chicago was chosen as third man. The Board reached a unanimous agreement as to the value of the properties in the latter part of 1921. The citizens by a large majority voted to purchase the properties at the agreed price. The existing plants were taken over and have been operated as municipal properties since 1922.

The City of Orlando was then confronted with the utility problem which it took prompt steps to solve. Realizing the advisability of

[1] Presented before the joint sessions of the Illinois, Iowa and Wisconsin Sections, March 17, 1925.

[2] Assistant Engineer, Alvord, Burdick and Howson, Chicago.

keeping the utilities free from political influence and of having a continuing personnel and policy, the City Commissioners appointed the Orlando Utilities Commission, consisting of five of the city's most successful and influential citizens. The permanence of this Commission was subsequently assured by an Act passed by the State Legislature.

The Utilities Commission selected as its advisors, Alvord, Burdick and Howson of Chicago, who investigated the best means of correcting existing deficiencies, prepared plans and specifications, and supervised the construction of the necessary improvements.

Both the water and light plants required rehabilitation and enlargement. The electric plant could not meet the requirements even with all units in service, voltage was uniformly low, and interruptions in service were frequent. The water supply was taken from lakes. On account of inadequate filter capacity about one-half of the supply was unfiltered.

The determination of the best provision for future requirements was not so simple as in the average city. Orlando up to 1910 had not developed very rapidly. In the period from 1890 to 1910 there was only a slight increase in population, but from 1915 to 1920 the population more than doubled, and the rate of growth was about 20 per cent per year at the time the plants were taken over.

The population of Orlando in 1920 as given in the United States Census was 9282. The number of services connected during 1920 and 1921 indicated that the rate of growth in these years was much more rapid than previously obtained, and that a particularly liberal estimate of future growth was desirable. This was also indicated by the growth of other Florida cities studied, for the entire state had recently been and still is experiencing a remarkable growth. It was estimated that the population of Orlando would be 50,000 by 1950. This is now believed to have been rather too conservative. The improvements built in 1922 and 1923 were designed for 30,000 people.

THE SOURCE OF WATER SUPPLY

Orlando is located in the "Lake region" of Florida, there being 17 lakes of varying size within the city itself. Several lakes were available as sources of supply. Hydrographic surveys were made to determine the storage capacity of the lakes. Rainfall and runoff, and the yield of watersheds were studied from the local and other records. The top soil is all sand in this section. There is no natural

surface runoff, but the rainfall which averages 60 inches per year largely percolates through the sand to the lower impervious strata, thence to the lakes where it is stored in beautiful bodies of clear water of relatively high purity.

Ground water is also available in large quantities and with a static level near the ground surface at Orlando. Comparative studies of first and annual costs of well and filtered lake waters were made to determine which supply would be the most practicable. Analyses of water from existing wells showed that a softer and more desirable water could be obtained by filtering the lake water.

The water in the chain of lakes considered as best of the surface supplies had a hardness of approximately twenty parts per million and forty-one parts per million of incrusting solids. Alkalinity with phenolphthalein was zero, and about ten parts per million with methyl orange. These several lakes afforded storage and had sufficient drainage area to take care of the future needs of Orlando for at least twenty to thirty years. When an additional supply is required Lake Underhill located about two miles east of the city and about 25 feet above the first group of lakes can be utilized by building a conduit through which water would flow by gravity to the first group.

The well waters, while not shown by analysis to have been contaminated at that time, were believed to be potentially unsafe due to the fact that the sewage of the city after being clarified by Imhoff tanks is discharged into wells which "drink" instead of yield. It is believed that heavy drafts for municipal supply would probably result in this sewage contamination reaching the adjacent wells.

It was decided, therefore, after comparing construction and operating costs and the quality and quantity available of both surface and underground waters to use the surface supply and develop first the drainage area of the group consisting of Lakes Highland, Ivanhoe, Concord, Adair and Spring as a source of water supply. These lakes provided a natural storage of 1,300,000,000 gallons.

The preliminary studies demonstrated the impracticability of utilizing any of the old power plant, pumping station, or slow sand filter plant as such. It was recommended that an entirely new plant be built on the shore of Lake Ivanhoe, this plant to contain the power, pumping, and mechanical filter plant all under one roof.

Statistics of the old water and light plant showed that the variation in seasonal loads for both utilities was greater than that ordinarily experienced in the northern cities. In the winter the electric load

was greatly in excess of the average daily load due to the influx of tourists and the operation of the packing houses, citrus fruits being packed almost exclusively during the winter season.

The pumpage naturally increased with the additional number of consumers supplied during the winter. Lawn sprinkling is more general in the winter because of this being the dry season. The soil is sandy, so that a week or two of dry weather is sufficient to cause the average daily pumpage to increase approximately 100 per cent for short periods and conversely a day or two of rain may cause the daily pumpage to decrease 50 per cent compared to the previous day's pumpage. These changes are of course of short duration but occur off and on throughout the year.

The size of the new units to be installed for water service were selected with respect to both the severe peak load conditions, somewhat greater than those experienced further north, and the minimum conditions which occur in the summer rainy season.

For the electric load, the population practically doubles during the winter with a resulting greater seasonal use of electricity than is experienced in this locality.

THE PLANT

Plans and specifications were prepared in the early part of 1922 and bids were received on August 30, 1922. Contractors bidding on the building and coagulating basin would not guarantee a time of completion so the city decided to do this work by day labor under the supervision of the engineers. This was done and the electric plant started to operate on June 1, 1923, and the filter plant on June 26, 1923. The plants have been operating since the above dates.

A station building 172 feet 6 inches long and 98 feet wide, overall dimensions, was required for housing the immediate installations as well as providing reasonable space for future units. This applies directly to space for future boilers and generators for additional filter capacity will be obtained by constructing filters adjacent to the present installation. The west portion of the building houses the boilers and electrical equipment, while the purification plant occupies the east end of the building. The pumping equipment is in the center of the building.

In view of the conspicuous location of the building, situated as it is on a main highway, and also in view of the designer's ideas as to the importance of a building housing the water supply of any community,

more attention was paid to the architectural appearances of the Orlando station than is customary in ordinary water works construction.

The Dixie Highway runs directly past the front of the building, the construction of which made it desirable to re-locate several hundred feet of the highway at this point. Thousands of tourists to south and west Florida pass by the building each year and many stop to inspect it. The building is visible for about ½ mile north and south on the Dixie Highway, and also from across Lake Ivanhoe so that it is the most prominent feature of the landscape, as Orlando is entered by auto from the North. The territory directly adjacent to Lake Ivanhoe enclosed by the highways that encircle the lake, is a city park and the grounds of the water plant are maintained so that they constitute an integral part of the park system.

The design of the building is an adaptation of the old type of architecture which developed during the Spanish era in Florida. The building is constructed mainly of reinforced concrete, but certain upper portions are of brick. The exterior is finished with a white stucco applied directly to the brick and concrete walls.

The roofs over the main building are not visible and are of concrete tile construction on steel trusses and purlins. The lower portions of the building over the filters and entrance lobby are provided with red Spanish tile roofs.

Entrance to the building is by means of a tile paved portal embellished with stone carving and iron railings. Entrance to the generator and pump room is through an attractive lobby whose walls and groined arch ceilings are treated to imitate cut stone. Public toilet rooms finished in marble are located on each side of the lobby. Located in the center of the lobby is a handsomely carved Spanish drinking fountain.

The floors of the lobby, generator and pump room are finished with red quarry tile.

The architectural treatment of the generator and pump room is of extreme simplicity, but carries out the Spanish idea in its general lines and color scheme. The effect of the room upon entering is of extreme light and airiness. The walls are finished in white paint above an olive green wainscoting. While the general color scheme is white the wrought iron work and machinery foundations are painted olive green.

Because the basement contained auxiliaries, low lift pumps and high voltage equipment, it was given particular attention relative to

lighting and ventilation. Windows on the front and south and large pit openings in the main floor provide an abundance of light and air.

In the boiler room in place of the conventional glazed windows large arched openings have been provided and equipped with wrought iron grilles typically Spanish in treatment. These unobstructed openings were not only adopted because of the architectural effect but because they afford an abundance of ventilation for a naturally hot room in a warm climate. They also provide a practical means of moving equipment in or out of the boiler room.

V. A. Matteson of Chicago designed the architectural features of the building.

A brief description of the various units installed in the new plant follows:

Three 512 horsepower water tube boilers constitute the boiler plant. These boilers are equipped with Power Specialty Company superheaters, Vulcan soot blowers and Schuette and Koerting oil burners. A working pressure of 225 pounds per square inch with 100 degrees of superheat is maintained. The Springfield Boiler Company of Springfield, Ill., furnished the boilers.

Owing to the high temperatures which result from the use of oil as a fuel, the combustion chambers of these boilers are somewhat larger than is customary where coal is used.

Some difficulty was experienced in the early operation of the boiler plant. The high temperatures developed with the use of oil caused the front walls of the boilers around the burners to burn out and these walls had to be renewed about every three months. It was discovered that the location of the burners with respect to each other and the inside of the front wall caused this trouble.

There are three burners to each boiler, two of the burners being located at the same height above the floor, symmetrical with respect to the center line of the boiler and the third burner below and centered between the other two burners. The wall opening at each burner is cone shaped with the base of the cone at the inside face of the front wall of the boiler. As first installed there was a wedge between the two top burners 6 inches thick. That this wedge was the weak part of the wall was indicated by failure occurring first at this point.

The difficulty experienced was remedied by moving the two top burners further apart. Another source of trouble was caused by the flame from the burners impinging on the edges of the openings on the inside face of the front wall and which resulted in the wall burning

off at this point. By extending the tip of the burner a few inches forward, this trouble was done away with. Since these changes have been made no further trouble has been experienced with the oil burning equipment.

Oil was adopted as a fuel because the price at which Mexican oils can be obtained in Florida makes this fuel more economical than coal. Oil is pumped to the burners at 175 pounds pressure per square inch after being heated to temperatures of 225° to 250°F. Vaporization is effected by pressure and temperature only, neither steam nor air being inducted into the oil as it is pumped to the burners.

Changes in load conditions are met by changing the tips which consist of a pipe $\frac{3}{4}$ inch in diameter by 24 inches long on the end of which is the tip proper. The tip is made of a high temperature resisting metal and the diameter of the orifices through which the oil passes varies from 0.75 to 2.5 mm. A few seconds is all the time required to change one of the tips and this feature is particularly convenient in meeting the peak loads of the electric plant which come on very quickly.

It is interesting to note the roomy appearance of the boiler room where stokers are not used, and also the cleanliness that is possible with an oil fuel. The boiler room walls were finished in white and after being in use over a year are still white.

The generating equipment consists of two 1500-k.w., 2300-volt A. C. Westinghouse turbo-generators, and one 1000-k.w., 2300-volt A. C. General Electric turbo-generator. The latter unit was moved over from the old plant. C. H. Wheeler surface condensers were erected with the Westinghouse units and the General Electric generator has a Westinghouse jet condenser. Two D. C. exciters were also installed, one being a turbo-generator of 50-k.w. capacity, and the other a motor generator set of 60-k.w. capacity.

Three low lift, three high lift motor driven centrifugal pumps and a small motor driven wash water pump constitute the entire pumping capacity of the water plant. Low lift and high lift pumps have capacities of three million gallons each against heads of 35 and 150 feet respectively. These pumps were furnished by the Morris Machine Works.

In addition to the motor driven pumps three steam pumps with a total capacity of five million gallons daily are maintained in the old pumping station ready for instant use.

Four filters were constructed having a nominal capacity of one

million gallons each when operated at two gallons per square foot per minute. The old slow sand filters were remodeled into two coagulating basins by raising the walls four feet and the installation of baffle walls.

The capacities of the new plant compared to the old plant are as follows:

4000 k.w. to 1780 k.w. in generators
1536 boiler horsepower to 1162 boiler horsepower
14 million gallons to 8 million gallons pump capacity

Comparison of total capacities does not indicate clearly the increased capacities of the new plant. The new boilers can be operated at 250 per cent rating while the old boilers as installed could carry but little overload. Increased efficiencies were obtained in all of the units installed. Higher pressures and efficiencies were developed with the new boilers. It is doubtful if the old water plant could have pumped the rated capacity of eight million gallons per day.

Water is taken from Lake Ivanhoe through a 30-inch cast iron pipe terminating in a 30-inch cross which is located about 350 feet from shore and in 22 feet of water. This intake is connected to a suction well built of reinforced concrete in which are located separate suction pipes for the low lift pumps and the circulating pumps connected to condensers.

The suction well is 14 feet in diameter with the bottom 11 feet below average lake level. The top of the 30-inch intake line is 5 feet below average lake level. Two sets of double screens protect the pump suctions.

Water is pumped by the low lift pumps to 16 aerating nozzles located over the mixing chamber at the rear of the plant. Aeration is provided to remove the odor and taste of algae which is quite prevalent in all of the lakes in this region and to lower the CO_2 content. The mixing chamber which is of the over and under type provides an eighteen-minute mixing period at a 4 million gallon rate.

Dry feed machines installed by the International Filter Company, contractors for the filter equipment, feed the lime and alum. Alum is applied at the first compartment of the mixing chamber and lime is applied after the water has passed through the first coagulating basin.

After passing the aerators and mixing chamber, the water flows through a 24-inch main to the coagulating basins located on the

grounds at the old plant. The slow sand filters were remodeled to provide the two coagulating basins. These basins may be used either in parallel or in series and when cleaning is necessary one basin only is used. The coagulating basins are not covered.

The capacity of the two basins is approximately 1,500,000 gallons affording a nine hour settling period at a four million gallon rate, or approximately eighteen hours during the present average day's use of 2,000,000 gallons. This long settling period is used to effect as high percentage of color removal as possible. This is the main purpose of the coagulating basin at this plant for the turbidity is normally less than 20 parts per million. From the coagulating basins the water flows by gravity to the filter plant.

Four filters having a nominal capacity of one million gallons each when operating at a rate of 125 million gallons per acre per day were installed. Manifolds and perforated laterals are of cast iron. Controllers are of the Venturi type, operating tables are of marble, and are provided with loss of head and rate of flow gauges. All valves are hydraulically operated.

The cast iron laterals are 2 inches in diameter with $\frac{1}{4}$-inch holes spaced 6 inches on centers. Laterals are spaced 6 inches on centers with orifices pointing down. Strainers are used only on a 12-inch cast iron manifold.

Effluent pipes from the controllers turn down into the clear well. Chlorine is applied to the filtered water as it passes through a 5 foot wall opening on the way from the filter effluent, to the pump suctions.

The clear well at the new plant has a capacity of approximately 400,000 gallons with 9 feet of water. It is connected by a 16-inch pipe to the clear well at the old plant which has a capacity of 300,000 gallons. The suction of one of the high lift pumps is connected to this 16-inch line, so that this pump can be used with either the new or old clear well as desired. The other two high lift pumps are connected directly to the new clear well only.

Aeration, coagulation and filtration produce an odorless and tasteless water from which practically all of the color has been removed. Color is usually present in the raw water to the extent of 75 to 90 parts per million, and this is reduced to 10 or 15 parts per million. The alkalinity of the raw water averages about 10 parts per million and the filtered water has an alkalinity of from 35 to 40 parts using methyl orange as an indicator.

Total hardness ranges from 15 to 20 parts per million in the raw

water and from 40 to 45 parts per million in the filtered water. This effluent is much softer than that obtained in most Florida cities, particularly those using an underground supply where the hardness varies from 300 to 1100 parts per million, before being treated to reduce this hardness. One city used water from a group of wells which had a total hardness of 1800 p.p.m.

Two elevated tanks of 250,000 gallons capacity each have been erected. These tanks are located in the southern and eastern parts of the city at some considerable distance from the pumping station, which is in the north central part of Orlando. During times of peak load they feed back toward the center of maximum demand and since installed have caused pressures to be more uniform under varying rates of pumpage.

No particular difficulties were encountered during the construction of the plant. The construction equipment used consisted of one steam concrete mixer with tower hoist, one steam hoisting engine and a tower for hoisting brick and mortar. Two small gasoline mixers were used on certain portions of the work. Labor conditions were ideal. Union labor from all sections of the country was available during the winter under open shop conditions and at a cost of but 65 cents to $1.00 per hour for the building trades.

Five water mains were laid under the tracks of the Atlantic Coast Line and Seaboard Air Line Railways which run past the rear of the plant. These mains range from 16 to 24 inches in size and since the soil consists mostly of sand extra precautions were necessary in this work to protect the trenches against cave-ins with railway traffic being maintained. All mains were placed with the top of the pipe 6 feet below the base of rail.

Installing the intake was an interesting feature of the work. This was accomplished by floating the 30-inch cast iron pipe to the location desired, and there sinking it.

The method followed was to first build a launching platform about 100 feet long and 6 feet wide of two inch lumber. This platform extended out into the lake about 50 feet at the start of the work. A 12-foot by 12-foot platform of large timbers and planking was then constructed on the launching platform on shore. This heavy platform was supported on rollers and was to serve later as a support on the lake bottom for the cross at the outer end of the intake line.

The 30-inch cross was then placed on the 12-foot by 12-foot platform, anchored by means of two sets of ½-inch round stay rods passing

over the cross and through the platform. The purpose of this support under the cross was to prevent it sinking into the soft material on the bottom of the lake.

Wooden bulkheads were caulked into three openings of the cross, oakum only being employed to insure water-tight joints. Steel cables with floats were attached to each bulkhead, so that they could be pulled after the pipe had been placed in its final location.

With the cross in position on the platform, pipe was added one length at a time also on rollers until several joints had been connected up and all available space on the launching platform had been utilized.

That part of the intake connected up was moved far enough forward on the launching platform to permit further connections to be made. Two sets of block and tackle were used to prevent the pipe getting out of control and sliding out into the lake.

Computations showed that the weight of Class "A" 30-inch pipe required additional buoyancy to prevent its sinking prematurely in the event of any material amount of leakage occurring at the bulkheads. Water-tight barrels were used for pontoons, two being utilized for about two lengths of pipe.

After a part of the intake line was floating the process was simple, care being taken, however, to prevent the line from sliding out into the lake. The shore end was naturally higher than the floating section and the pipe moved very easily, in fact almost too easily after several lengths of pipe were floating.

The bulkheads leaked slightly and water was pumped out of the intake line by a trench pump having wrought iron pipe connected to the suction. Additional lengths of wrought iron pipe were added as the intake increased in length.

After the intake line had reached a length sufficient to bring the cross over a predetermined point, pumping was stopped and the line allowed to fill. The time required to sink this line was approximately one and one-half hours.

Sinking the intake line left the shore end several feet above the final elevation of this end of the line. It was in line, however, with a 30-inch stub already connected to the suction well on which was located a 30-inch valve.

A suction dredge was employed to remove the sand under the pipe until it was at the proper elevation, after which the dredge was reversed and sand pumped back covering the pipe. A bulkhead pre-

vented the sand from filling in the section where final connection was to be made. An ordinary sleeve connection was used to connect the two sections of the intake line.

It was expected that a winch on the dredge would be utilized to pull the bulkheads. When this was attempted, however, it was found that the bulkheads had swelled to such an extent that the winch could not develop sufficient power to pull them from the cross, and it was necessary to use a diver to cut them out. A diving outfit was procured and one of the water works employees who has had previous experience as a diver cut out the three bulkheads in about one day. He also removed the barrels which had sunk with the intake line.

This work was completed without an accident and cost less per foot than laying 30-inch pipe under ordinary conditions in a trench. The intake line was installed by E. M. Austin, Water Works Superintendent for the Orlando Utilities Commission.

An examination of the distribution system showed that the pipes were very badly incrusted, and in some cases 4- and 6-inch pipes had openings so small that it was barely possible to pass sewer rods through them. Numerous tests of the distribution system showed that the average carrying capacity of the pipe tested was 30 per cent of that of pipe the same age, based upon Weston's Friction Tables. Some cleaning had been done before, but a general cleaning of the whole system had never been attempted. It was decided at this time to clean all of the pipe 4-inch in diameter and above, except one 16-inch which had been laid only a short time before.

This work was done by the National Water Main Cleaning Company. Approximately 20 miles of mains were cleaned, ranging in size from 4 to 12 inches. The cleaning increased the capacity of the system approximately 50 per cent with a resulting increase in pressure throughout the city. The cost of the work averaged 10.33 cents per foot, 8 cents of this being the contract price to the Cleaning Company and 2.33 cents the cost of labor supplied by the city.

The pressure maintained by the old company in the center of the city except at times of fire was 25 pounds per square inch. This was increased to 35 pounds per square inch when the city took over the old plants and since the new plants have been operated, the pressure maintained varies from 60 to 65 pounds per square inch. The city is comparatively level and pumping engines are used for fire fighting, so it was felt that a higher pressure would not be justified.

Besides raising the quality of service provided heretofore, the new

plant has proved very economical in operation which was forecasted when estimates of cost of construction and operation were prepared. The greatest economy which resulted from the installation of the new boilers and generators has been in the oil consumed. The saving in oil alone is sufficient to pay approximately 10 per cent interest on the investment in the new plant which more than justifies the expenditures made.

A very small operating force is required, one operator, one oiler and one fireman constituting the operating force on each eight hour shift for the electric plant, filter plant and pumping operations. The operator is in charge of the plant during his shift and is responsible for the continuity of service both of the electric and filtration plants. He is assisted by the oiler who washes the filters, watches the dry feed machines, and keeps the hoppers filled with coagulant. With oil burning equipment one fireman only is required on a shift. The plant as a whole is in charge of the Chief Engineer with mechanics, boiler washers and laborers as needed.

The layout of both the water and electric plants is such that additions may be made as future demands arise without losing any of the first investment. Additional filters may be built adjacent to the present filters on the east and the pipe gallery and piping extended. Pipe now installed in the pipe gallery is adequate for a filter plant of more than double the capacity of the present plant. Space is also available for additional coagulating basins.

In the generator room space has been provided for one additional generator which when installed will be larger than any of the present generators. When still further capacity is required the present No. 1 unit or 1000-k.w. turbo-generator may be replaced or the building extended, the program to be followed at that time depending upon the more economical of the two procedures.

In the boiler room, space is available for another boiler. At the present time one boiler out of three is sufficient to carry the load except at peaks during the winter months when a second boiler is used to help out for a short time. Additions to the boiler plant will follow in a general way increased generating capacity.

The water and light plant functions under the administration of a Board constituted by act of legislature, and is entitled the Orlando Utilities Commission. This Board consists of five members, each of whom serves for six years and without remuneration. The Board elects one of its own members President. The first Orlando Utilities

Commission was appointed by the Mayor and consisted of the Presidents of the four banks and the President of the Building and Loan Association. The success of the Municipal Water and Light Plant at Orlando is due in no small measure to the efforts of this first Commission who assisted very materially in financing the plant to its completion.

The construction of the plant and the installation of equipment were under the supervision of the writer who represented the Consulting Engineers on this work.

DISCUSSION

L. I. BIRDSALL: What were the pressures before and after main cleaning?

W. W. MATHEWS:[2] This work was completed before the new plant started to operate. It was necessary to maintain about 90 pounds pressure at the station to insure 35 pounds at the office downtown. After cleaning 60 to 65 pounds at the station would give 35 pounds pressure at the downtown office.

L. I. BIRDSALL: What was the depth of water at the outer end of the intake line?

W. W. MATHEWS: The cross at the end of the intake line was located in 22 feet of water. It was expected that the depth of water at this point would be ten feet but dredging for the new location of the Dixie Highway increased the depth of water very materially on the side of Lake Ivanhoe where the new plant is located.

L. I. BIRDSALL: What is the temperature of the water?

W. W. MATHEWS: The average temperature is about 80°F. or a little above. For a very few days in the winter it gets below 70°F.

L. R. HOWSON: There is no choice between the temperature of water from wells or from the surface supplies. The temperature of the well water is 74°F.

IMPROVEMENT OF SETTLING BASINS[1]

By W. H. Kimball[2]

In 1901 the Davenport Water Company constructed at its main pumping station on the Mississippi River a concrete sedimentation basin with a capacity of 3,700,000 gallons. This basin is somewhat irregular in shape, this being necessary to accommodate it to the available land. Its total length is about 470 feet, its width at the west end 128 feet, and at the east end 67 feet. The average depth of water in the basin is about 12 feet.

This basin as built had no division walls or baffles and has been in continuous use since it was built. The water from the river is pumped through a 24-inch cast iron pipe which discharges near the east end of the basin. The sulphate of alumina used as a coagulant, enters this 24-inch pipe beyond the west end of the basin, and the water from the sedimentation basin passes from it to a battery of 12 pressure filters, located in the filter building to the west. The plant has always been carefully operated, and water of an excellent quality has always been furnished, although within a few years after the sedimentation basin was put into operation it was realized that better results could be obtained from it if it were divided into two or more compartments, and plans for such a division were prepared prior to the War. Finally, late in 1922, a plan for a wall dividing the basin transversely into two approximately equal compartments was approved, and in March, 1923, a contract was made for this construction.

The division wall was built in September, 1923.

A section of the wall shows that it forms a deep narrow trough, the water from the east part of the basin flowing into this trough over the top of the concrete wall which forms a weir.

After entering the trough the water flows downward, along the whole length of the wall, to an opening controlled by a 30-inch gate valve at the center of the wall and near the bottom. In an emergency

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Consulting Engineer, Davenport, Iowa.

it is possible by opening another 30-inch valve to pass the water directly from basin 1 to basin 2.

The hollow space within the division wall may be provided with baffle planks to still further regulate the flow to the gate valve, although these baffles have not been installed.

It will be apparent that drawing the water from the east basin over a shallow weir practically the full width of the basin, creates a slow, even and undisturbing flow, so that sedimentation in the east basin is very complete.

The water enters the West basin or No. 2, in a clear condition, and flows from No. 2 into No. 3, which is a small semi-circular basin,

TABLE 1

Quantity of sulphate of alumina used, in grains per gallon, monthly averages, for the twelve months immediately preceding construction of cross wall (1), for the twelve months immediately succeeding construction (2) and the average for the fourteen years ended January 1, 1924 (3)

MONTH	1	2	3
October	2.56	2.74	3.33
November	2.19	1.59	2.72
December	2.24	1.49	2.30
January	2.21	1.24	2.23
February	2.56	1.68	2.80
March	3.07	2.57	3.72
April	3.51	2.68	3.15
May	2.82	3.25	3.45
June	4.08	4.17	4.23
July	5.40	4.02	4.09
August	4.34	4.13	4.05
September	4.07	3.11	3.69

where it is given a final dose of sulphate of alumina before going to the filters.

At all times a dose of chlorine is also given the water in basin No. 3.

After the construction of the division wall in September, 1923, a summary of the new plan of operation was prepared by the Davenport Water Company (see table 1).

The cross wall was completed and basin put in service September 28, 1923.

The turbidity of the raw water for the twelve months after the wall was constructed was generally higher than during the twelve months

preceding, especially in the months of June, July and August. The average turbidity of the water treated with alum recorded in column 1 in June, July and August was 187, 211 and 113 respectively while in the same months in 1924 the average turbidity was 326, 382 and 450 (column 2) showing that less alum was used to treat water having much higher turbidity. The maximum turbidity in August, 1923, was 275 (column 1) the maximum turbidity in August, 1924, was 900 (column 2).

In August, 1923, the average number of colonies counted on agar at 37 degrees was 19,600 for raw water and 14 for filtered water. In August, 1924, the corresponding figures were 13,400 and 16.

It should, however, be stated that the quantity of sulphate of alumina used here is not governed directly or entirely by the turbidity. Other factors such as algae and bacterial pollution sometimes control in determining the proper dose of chemicals.

During the winter of 1924 plans for additional improvements to the settling basin were prepared, and these plans were carried out in September and October, 1924.

These improvements included a mixing chamber, a chemical storage house adjoining the division wall in basin 2 and a baffle frame and baffles extending entirely across the west end of basin 2, together with a valve box or chamber into which the water enters after passing the baffles.

The mixing chamber is of reinforced concrete, 12 feet wide, 30 feet long and 12 feet deep. It is provided with brick baffle walls about 30 inches apart extending to just above the water surface. These baffles aid in efficient mixing of the chemicals with the incoming water from basin 1.

The mixing chamber is covered with a reinforced concrete slab, and is entirely enclosed on top by a brick superstructure.

The baffle frame at the west end of basin 2 is of reinforced concrete with 1½-inch by 6-inch cypress baffle planks. Its purpose is to prevent direct flow through basin 2 to the outlet, the baffle openings being so proportioned that the flow takes place along the entire length of the baffle.

The valve chamber was a necessary adjunct to permit and control the flow back of the baffle into basin 3. It is built of reinforced concrete and provided with two 24-inch gate valves and operating stands.

The designs of the reinforced concrete work were all quite simple

and present no unusual features. There was no attempt made to build the lightest sections possible. On the contrary the work is all substantial.

All of the cement used in the work was tested at the University of Iowa; sand, gravel and stone were carefully selected, and in part of the work, such as the division wall, were carefully graded.

Proportions were 1:1½:3 for the division wall, and 1:2:4 for the rest of the work. All of the work is water-tight, and all submerged steel is protected by at least 3-inches of concrete. No waterproofing compounds were used nor required with the carefully graded mixtures employed.

The Priester Construction Company of Davenport were the contractors for all of the work and deserve credit for the rapidity and throughness with which it was done.

The plans were largely due to local conditions and followed the design of the basin which was piped for an expected division at the time of original construction. Observations and experience of the operators were also considered in the final arrangement.

The engineering features of the work, the designs, the preparation of the plans, specifications and contract, and the carrying out of the construction were under the personal supervision of Wm. H. Kimball, Consulting Engineer.

SAMPLING OF FILTER SAND

By W. S. Mahlie[1]

We have always had a little curiosity regarding the sampling of filter sand, especially as to whether the samples ordinarily taken represent with fair accuracy the composition of the entire lot of sand. A good opportunity presented itself recently during the construction of some additional filter beds, to check up on this special problem.

The sand generally used for filter plants in this part of Texas, is obtained from Goliad, Goliad County, Texas, and is known as Goliad Sand. Numerous tests made at different times have indicated this sand to be about 0.29 to 0.31 mm. effective size, and about 2.15 uniformity coefficient. Inasmuch as this sand apparently was a little too fine, it was decided to place the sand in the filter beds, wash it and then scrape it until the proper size was reached. Accordingly the sand was treated in this manner. The results obtained are shown on table 1.

Regarding the methods of sampling, the samples marked "grab sample" were taken by simply picking up a small portion here and there, after the sand had been placed in the filter beds, but before washing. The samples marked "core sample after first washing" were taken as follows: After the sand had been washed, the filter waste valve was opened and the excess water allowed to drain out. A piece of 2-inch copper pipe about 4 feet long was then pushed down into the sand for a distance of 6 or 8 inches and then carefully withdrawn. The wet sand packed itself in the tube nicely and was then dislodged easily by striking the tube lightly on the side. The process was repeated until the core was cut through to the gravel layer.

The samples marked "6 inches below surface" were taken at a point 6 inches below the surface of the sand bed, and represent the sand at the 6-inch depth, but do not represent the top 6 inches of sand.

The same is true for the samples marked "12- to 15-inch depth" This depth represents the point half-way between top and bottom of the sand bed.

[1] Chemist in Charge, Filtration Plant, Fort Worth, Texas.

The final samples after washing and scraping represent the sand as finally accepted. In all, about 4 inches of sand were scraped from the top of each filter bed.

This test brings out the following facts:

1. The grab samples and the core samples are in fairly close agreement.

2. A hydraulic grading takes place during washing.

3. Samples taken at certain predetermined depths are affected by

TABLE 1

Filter sand tests

FILTER NUMBER	GRAB SAMPLE		CORE SAMPLE		6 INCHES BELOW SURFACE		12 TO 15 INCHES BELOW SURFACE		FINAL SAMPLE	
	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.
9	0.30	2.07	0.29	2.02	0.32	1.28	0.48	1.52	0.37	1.78
10	0.30	2.10	0.31	2.03	0.32	1.68	0.33	1.88	0.38	1.92
11	0.31	2.10	0.33	1.85	0.32	1.56	0.35	1.77	0.36	1.92
12	0.33	2.15	0.30	2.19	0.35	1.26	0.48	1.60	0.39	2.00
13	0.31	2.00	0.32	1.88	0.33	1.24	0.41	1.29	0.36	1.72
14	0.34	2.18	0.33	1.97	0.35	1.32	0.44	1.55	0.36	1.86
15	0.31	2.03	0.30	2.00	0.32	1.28	0.44	1.39	0.37	1.89
16	0.31	2.10	0.32	2.19	0.33	1.33	0.43	1.56	0.39	1.82
Average..	0.31	2.09	0.31	2.02	0.33	1.37	0.42	1.57	0.37	1.86

the depth at which they are taken, and approach unity as a uniformity coefficient.

4. A midway point is not a representative sample, nor is the top 6-inch sample a representative sample of the entire bed.

The conclusions we draw from this little experiment indicate to us the need for something to take the place of our present effective size and uniformity coefficient methods of judging filter sands used for rapid sand filters.

FINANCING WATER MAIN INSTALLATIONS[1]

By D. A. Reed[2]

The term "financing of water main installations," it is taken, means not merely the job of procuring the money and paying for the extension, but the method of assessing or fixing the cost of these extensions upon the proper parties, either by some process of assessment where the plant is municipally owned, or by the use of guarantees or other arrangements in the case of the privately owned plant. Much confusion seems to exist and there are almost as many different methods of handling these matters in both municipal and privately owned plants as there are plants.

Frank C. Jordan, Secretary of the Indianapolis Water Company, has procured some valuable data on this subject which are printed in the September, 1924, number of The Journal. This report shows many typical illustrations of the methods used.

In one case the property owner pays the cost of the mains in full in front of his property. This seems to be inconsistent with good business practice for several reasons. First, the customer of any business or of a utility is not supposed to pay direct capital investment and in addition pay earnings upon the same investment. In fact, a business of any kind should be conducted upon the basis of ownership of all of the plant necessary to conduct the business, and the customer should not be assessed for capital investment except such share of the rates charged for the commodity furnished as a customer pays when he meets his current bills. As it is impossible to pay for the entire plant by this method and, owing to changing methods, even to pay for all the extensions, it would seem evident that one customer or class of customers would be assessed where the remaining customers would not be. Consequently, this method would be unfair. Also where property is assessed a certain amount per front foot, for instance as at Washington, D. C., or Reading, Pa., or where

[1] Presented before the Minnesota Section meeting, November 14, 1924.

[2] Manager, Water and Light Department, Duluth, Minn.

any amount is assessed as a part of the capital investment and where this amount approximates the cost of the main, it results in making the property owner pay for the main and also earnings upon the same investment. We might go through the whole list of cities quoted by Jordan and find some injustice in connection with the methods used. There is one method, however, used at New Britain, Conn., where they have an assessment of 10 per cent of the cost of the main assessed against the abutting property for ten years. If this 10 per cent is a proper charge for the capital investment necessary to make the extension it would seem to be a method of some merit. However, there seem to be no credits provided for upon this assessment for the overhead charges which are met by a portion of the water rates, consequently the customer is paying for this item something more than what would be just if he is a customer and paying the regular rates for water furnished.

Before formulating a method which would be ideal it would seem necessary to establish certain principles. As a tentative guide the following are suggested:

1. Whether the utility is privately or municipally owned it should be organized with its own and separate fund independent of all other funds, especially the municipal plant with its entire revenue derived only from the sale of water and such service as it may render, with free service to none and a charge to all based upon the cost of service rendered.

2. The rates should be sufficient to cover all operating expenses and fixed charges including depreciation, and in addition a sufficient margin to retire its indebtedness within a reasonable time. As a municipally owned plant or as a privately owned plant it should furnish a fair earning upon the capital invested.

3. Both plants, whether municipally or privately owned, should have a working surplus of available cash sufficient to meet the cost of ordinary extensions without borrowing or bonding the plant. Exceptions might be made to this where a city is growing too rapidly or where extraordinary large extensions are made in one year. This would answer the question as to financing, strictly speaking, of water main extensions.

4. The cost of extensions should be borne only by the parties served and should not be a burden or a tax upon the original plant.

5. If overhead and operating expenses are forthcoming from its

customers immediately upon the installation of the extension, all difficulties cease and there is no problem to solve.

In the making of extensions, however, it is seldom that all of the above conditions prevail. The most troublesome one is that there are not sufficient customers to furnish revenues sufficient to meet all of the expenses enumerated in clause 2 above. In examining the incomes derived usually from new extensions we find that the *operating expenses* in the sale of water to the individual customer is sufficiently met by the rates paid by the customers in almost every instance. However, when it comes to the matter of the *overhead expense* or *fixed charges* on a capital investment it is entirely different. One extension with no customers would pay none of this expense. With a few customers they would be able to pay a portion of that expense as represented by that factor of the rates paid which represents overhead expense. If there were sufficient customers and enough business upon the extension to meet all expenses, both overhead and operating, no assessment or guarantees of any kind would be necessary. Consequently, if it cannot be determined in advance how profitable an extension may become after it is installed, it would seem necessary to adopt some means of assessment in the municipal plant by which the deficiency in revenues could be met by those that are interested in the extension or are benefited by its installation. It is suggested as being practicable that, at the end of the year after an installation is completed, that portion of the rates paid the utility for water furnished by this extension which goes ordinarily to meet overhead expenses and fixed charges be separated from the balance of the rates which go merely to meet operating expenses (such for instance as the pumping of water, the reading of meters, the making out of bills, collecting monies, etc.). This may amount to four or five per cent on the capital investment and generally runs from one-third to one-half of the rates charged for water where rates cover all expenses.

This should be applied upon the fixed charges of the extension and the balance assessed against the abutting property served or benefited. This would seem to meet every requirement and is what the writer believes should be adopted for the solution of this problem.

In connection with this method I wish to explain what has been done in Duluth and perhaps the better way would be to read this Ordinance:

ORDINANCE No. 489

By Commissioner Merritt:

AN ORDINANCE PROVIDING FOR THE EXTENSION OF WATER AND GAS MAINS IN THE STREETS AND OTHER PUBLIC WAYS OF THE CITY OF DULUTH, AND PROVIDING FOR THE ASSESSMENT OF PART OF THE COST THEREOF AGAINST THE PROPERTY BENEFITED THEREBY

The city of Duluth does ordain:

Section 1. Whenever the council shall order the extension of water and gas mains, upon a petition, as provided by section 62 of the charter of the city of Duluth, and upon the completion of said extension and appurtenances, or any part thereof, an assessment shall be made against the property specially benefited by such extension or portion thereof so completed, which assessment shall be payable annually, for a period not exceeding fifteen (15) years, and for each year shall be eight per cent (8 per cent) of the total cost of said extension, including engineering and other expenses, or so much thereof as may be completed.

Provided, however, that said assessment may be reduced or discharged in the manner hereinafter provided.

Provided further, That in determining the cost of any extension assessed under the provisions of this ordinance, any cost, arising from the laying of mains larger than six (6) inch mains for water and four (4) inch mains for gas, over and above what would be the cost of such six-inch and four-inch mains respectively, shall not be included.

Section 2. An extension shall be deemed completed when either water or gas is turned on in such extension.

Section 3. Said assessments for extensions shall in all cases be made against the property specially benefited thereby.

Section 4. Assessments made under this ordinance shall be made by the registrar of the water and light department, who shall make an assessment roll containing in columns the name of the owner of each lot or parcel of land separately assessed, if known to him, a description of each lot or parcel of land, and the amount assessed separately against each lot or parcel of land; and the assessment roll shall be so kept as to show the continuing nature of it for a period of fifteen (15) years, and all payments or credits made or to be given; and said assessments may be, if necessary, revised from year to year.

Section 5. The engineer of the water and light department shall make and forward to the registrar a plat and survey of the proposed extension and the property to be assessed, which plat shall be attached to the assessment roll; and the said engineer of the water and light department shall, before the registrar makes the assessment, furnish to the registrar a certified statement of the cost of the improvement and the engineering and other expenses in connection with said improvement.

Section 6. The registrar shall certify an assessment roll to the council, and thereafter the city clerk shall give ten (10) days' notice, by one publication in the official paper of the city, that the assessment roll is on file in the clerk's

office, which notice shall describe the extension and shall state a time at which the council will meet to hear the appeals of parties aggrieved to such assessment.

Section 7. At said time the council shall meet and hear and determine upon all objections which may be made by any party interested, to the regularity of the proceedings or to the correctness of the amount of such assessment, or of the amount levied upon any particular lot or parcel of land; and if the proceedings are found to have been regular, they shall correct any errors which may be found in the assessment, and shall thereupon, by resolution, approve and confirm such proceedings; and the proceedings and assessments, as so confirmed, shall thereafter be deemed the final determination of the regularity, validity and correctness of the assessment and the amount thereof.

Section 8. After the completion of said extension, whenever any water or gas is served to any property upon said extension, credit shall be given upon the assessment against the property so served, amounting to one-half of the total receipts for water, and one-third of the total receipts for gas, for each year;

Provided, that the council may at any time previous to Jan. 1 of each year change the proportion of water and gas receipts which may be applied in credit upon the assessments.

Section 9. Such assessment shall be deemed entirely discharged, together with the lien thereof, whenever one-half of the total gross receipts from the sale of water, and one-third of the total gross receipts from the sale of gas in said extension, shall equal or exceed for one year the total amount of such assessment.

Section 10. Assessments, or the unpaid portion thereof, may be paid in full in one payment by any property owner, by paying the balance due thereon, less 25 per cent of said balance.

Section 11. On or before the first day of October of each year, the registrar shall certify to the city council a statement of all assessments delinquent under this ordinance, describing the land affected, and giving the amount of the assessment, with penalty added, after which the assessment shall follow the provisions of section 70 of the city charter.

Section 12. So far as relates to assessments for the improvements described in this ordinance, this ordinance shall be deemed to supercede all prior ordinances.

Section 13. This ordinance shall take effect and be in force thirty days after its passage and publication.

Passed June 8, 1914.
Approved June 10, 1914.

W. I. PRICE, Mayor.

Attest:
C. S. Palmer, City Clerk.

By a study of this ordinance it will be noted that only deficiency revenues are assessed against the abutting property, that is, such shortages as are not available in the rates paid for water by the regular

customers, and only until there are sufficient customers on the extension so that the overhead factor in these rates meets the overhead expense of the investment in the extension. Then all assessments cease. The City has just completed near Morgan Park an extension costing over $18,000.00 in which the 8 per cent assessment is over $1440.00. There is not a single house upon this extension and all of this $1440.00 is, under this plan, due and payable to the Department within forty days from the completion of the work and the same

TABLE 1

Statement of assessments, Duluth, Minn.

December 31, 1923

YEAR COMPLETED	ORIGINAL ASSESSMENTS		ASSESSMENTS DISCONTINUED UP TO DECEMBER 31, 1923		ASSESSMENTS IN FORCE DECEMBER 31, 1923		NET AMOUNTS LESS CREDITS FOR USES DECEMBER 31, 1923	
	Number of assessments	Amount	Number of assessments	Amount	Number of assessments	Amount	Number of assessments	Amount
1914	17	$1,498.32	11	$1,085.04	6	$413.28	6	$219.66
1915	59	5,763.44	34	2,678.85	25	3,084.49	25	1,688.01
1916	66	7,821.47	31	2,716.05	35	5,105.42	35	2,389.24
1917	48	8,496.98	12	2,395.73	36	6,101.25	36	3,618.25
1918	9	1,729.62	3	350.78	6	1,378.84	6	1,001.00
1919	19	5,629.12			19	5,629.12	19	4,234.32
1920	39	9,179.57	3	174.46	36	9,005.11	36	7,047.11
1921	31	12,034.72	2	78.85	29	11,955.87	29	8,826.56
1922	39	6,999.56	1	28.72	38	6,970.84	38	5,748.26
1923	55	9,732.30	1*	88.84	54	9,643.46	54	9,338.20
	382	$68,885.10	98	$9,597.42	284	$59,287.68	284	$44,110.61

* K 49 cancelled.

amount is paid each year for a period of fifteen years provided there are no customers. This would amount in the total to $21,600.00. In other words, $21,600.00 is what the Department would receive as payments for an investment of $18,000.00 for fifteen years, in case no customers were over obtained that were tributary to the extension.

In comparison with this we will suppose that the extension was made into a thickly settled district or one that built up very rapidly the first year so that the total annual revenues from this extension amounted to not less than $2880.00. If it had been decided that the

overhead expense of the entire plant was one-half the total of the whole expense, including operation, $1440.00 would be credited on this assessment which would cancel the assessment the second year. Of course, it would not be possible to cancel the first assessment immediately on the completion of the extension for the reason that there would be no customers and no credits the year previous to the completion of the extension. It is not possible to go into all of the details of the plan which has been worked out. However, the above seems to be sufficient to give a comprehensive idea of how the plan works and what its advantages are. This plan was first installed in June 1914 and has now been in operation for over ten years. Table 1 is a résumé of its operations during that time.

It is believed that a State law might be passed which would authorize cities generally to make assessments in accordance with the above plan or authorize cities to assess deficiency revenues. It is, however, thought that the plan would be just as desirable for private corporations as for a municipal plant, and perhaps also for street railways and gas plants and certain other utilities.

The plant at Duluth, of course, includes both water and gas and the assessments are combined and made in one. The difference between the water and gas is that credits from gas receipts are one-third, whereas the water receipts are one-half the rates or revenues.

It will be observed that the ordinance can be amended at any time to permit necessary changes in the percentage rate of assessment or to change the fraction representing credits in order to fit existing or changing conditions.

The citizens generally are well pleased with the plan. The assessments are light, running from $2.00 to $10.00 per lot where there is no rock (this also includes gas mains), and with credits for consumers who eliminate the assessment in almost every case. In the 382 extensions made in the past ten years, there has been but one appeal, the court deciding that the assessment should be made by frontage instead of by area. Since then the ordinance has been changed so that assessments can be made either by frontage or area methods. There are many interesting features in connection with this method that it would be profitable to discuss, but enough has been submitted, it is believed, to start discussion.

NIGHT PUMPAGE RATES[1]

Topical Discussion

E. J. Jenkins:[2] The East Chicago Plant, which I will use for the basis of my discussion, is 100 per cent metered. I find on checking the meter records of this plant for the year 1924, that 18 per cent of the total water pumped is pumped between 12 midnight and 6:00 a.m.

We have in East Chicago 61 large industries, who use 58 per cent of the total water pumped. These plants run twenty-four hours, and I think it fair to assume that the water pumped in these hours is used by these consumers.

In 1924 the per capita pumped was 138 gallons, of which the industries used 58 per cent, or 80 gallons, leaving domestic per capita, 58 gallons.

In taking a pumping station meter chart at random, I find that the minimum rate on a normal day is approximately 150,000 gallons per hour. This figured against the population gives 80 gallons per person per day, which is an exact check of the average per capita demand that our actual metered sales show went to the industries.

In other words, I am satisfied that our night load is practically all accounted for by industrial use.

Wm. Luscombe:[3] In the discussion of this subject, the speaker desires to stress the fact that it is so closely allied to and interwoven with that of waste and losses in the distribution system, one cannot fully discuss the first without considering the others, so he asks your kind indulgence for the latitude taken.

In determining the night rates as well as the day flows, he desires to emphasize the importance of first knowing the accurate quantities pumped or flowing into the force mains and distribution system, the

[1] Presented before the Indiana Section meeting, January 23, 1925.

[2] E. J. Jenkins, formerly with East Chicago Water Works; now with Philadelphia Suburban Water Works, Philadelphia, Pa.

[3] Vice-President, Gary Heat, Light and Water Co., Gary, Ind.

entire twenty-four hours. Regardless of what devices, apparatus, or methods are used, frequent accuracy tests and check-ups are essential, if correct information is always obtained.

In many cities and towns the total output is based upon the number of pump strokes, which are taken at face value. In other places allowances are made for slippage ranging from 5 to 20 per cent or more. Some years ago, the speaker was in charge of a plant where that method of computation was used. Five per cent allowance was made for pump slippage when he assumed charge. Shortly afterward, tests were made and 14 per cent slippage was found in one pump and 18 per cent in another. This condition is typical and "Old Man Slippage" is still doing a "kidding" business and his proportions are such an unknown quantity in many places that he is responsible for a vast amount of misinformation in recording the total water supplied.

In other places, and, no doubt, in many instances where special metering devices are used to record the total supplied or pumped, one might well question whether or not its efficiency equals approximately 100 per cent throughout the twenty-four hours. The showing may be all that could reasonably be expected under a day flow or a peak load rate and yet make a miserable record under a low night flow. This has been the experience of the speaker and he believes it is not uncommon. In justice to manufacturers, it should be stated that, on account of the wide range of conditions under which some metering devices operate, it is hardly fair to expect them to make a 100 per cent record all of the time.

When the actual amount of water pumped or flowing into the distribution system during the night time as well as during the day period has been accurately and definitely fixed, an analysis of what becomes of all of it may be in order. For the purposes of this discussion, remarks will be limited to that part of the demand made between midnight and 6:00 a.m. During 1924 our daily average pumpage was approximately 5,200,000 gallons, practically all taps are metered, and our population is about 80,000. The percentage of the total pumped per twenty-four hours, that passes out of the system between midnight and 6:00 a.m. during non-sprinkling months, ranges from 12.7 to 16.6 per cent and averages 15 per cent. These variations are due principally to changing business conditions, seasons of the year, etc. For instance, during extreme cold weather the night flow is increased as much as 20 per cent on account of

customers permitting faucets, etc., to run to prevent pipes and fixtures from freezing and bursting. On hot, dry evenings when lawn sprinkling is carried on extensively, the delivery per minute for short periods is six times as great as that of the latter part of the night flow which, however, is not affected by that use.

As mentioned, the demand for the six-hour period ending at 6:00 a.m. averages 15 per cent of the day's total (5,200,000 gallons) or 780,000 gallons. Our records show that an average of 84.5 per cent of total daily average pumpage or 4,394,000 gallons is registered by meters on customers' service pipes plus small miscellaneous uses. This leaves a balance of 806,000 gallons per day which we consider chargeable to "unaccounted for" or leakage in mains and services. To ascertain the estimated leakage in mains and services during the six-hour period, one fourth is taken of the 806,000 gallons, which is 201,500 gallons. If this amount is deducted from the total pumped during the six-hour period (780,000 gallons) there are left 578,500 gallons, or about 74 per cent of that total which it is estimated passes through customers' meters during that period.

According to inspections made, the principal users of water between midnight and 6:00 a.m. are: Industrial and ice manufacturing uses, locomotive tank filling, garages, dairies, bakeries, hospitals, industrial workers homes on account of time in changing shifts, lunchrooms, hotels and soft drink places.

Recently, it was found that about 20 per cent of the night flow was being registered by five meters of the users mentioned.

Of course, some of the foregoing list of users, as well as other customers, are also water wasters, as they permit such fixtures as faucets, drinking fountains, closets, urinals, etc., to run continuously, but as they pay for all water furnished by meter measurement, the waste inside of buildings is curbed to a great extent.

Granted we are paid our regular meter rates for all water furnished the consumer, we take the position that unsuspected waste paid for by him creates dissatisfaction and in a friendly spirit, we make it our business to show him, if we can, the cause of the high bill so that he will be better enabled to apply the proper remedy. We believe this coöperation and voluntary service is invariably appreciated.

Another form of waste that vitally interests us, of course, is that of the unmetered class, or losses in the distribution system and the best method of checking it.

We make frequent pipe line leakage inspections and, as many

leaks exist that give no surface indications, we have experienced men who use metal rods for sounding locations of mains and aquaphones to locate breaks.

We also ascertain the extent of the leakage into some suspicious sections of the distribution system by closing the gates, using the hose from one fire hydrant to another, and measuring the flow into the segregated section through a meter connected into the hose line.

We obtain very good results with both methods.

For extensive water waste surveys, no doubt, pitometer tests are far preferable.

In fairly comparing the percentage of that portion of the total pumpage term "unaccounted for," it should be borne in mind there is a great variation in the pressure carried in different cities and towns, and it is very important that this item be taken into account as well as other factors such as mileage of mains in their various sizes; number, size, and mileage of service pipes; percentage of taps metered, etc.

The speaker believes that the extent of distribution system losses or the percentage of water "unaccounted for" in any water plant depends largely on the interest displayed and action taken by those in authority, to check it, and that eternal vigilance and wise painstaking methods are absolutely essential if such losses are reduced and kept to a minimum.

J. O. ENDRIS:[4] I am giving you herewith statistics which we have compiled for the past year on our properties at Jeffersonville, giving briefly percentage of consumption from midnight to 6:00 a.m.

We have especially accurate data on our Jeffersonville distribution system, inasmuch as all water being pumped into the city is being registered through a venturi meter at the pumping station. The percentage varies during certain months of the year and I am giving below the results of the twelve months past (1924):

	per cent		*per cent*
January	19	July	11
February	17	August	11
March	17	September	14
April	22.5	October	13
May	11	November	15
June	17	December	18

[4] Superintendent, Water Department, I. P. S. Co., New Albany, Ind.

This gives an average demand of 15.7 per cent. Therefore we know fairly accurately what percentage of water pumped from our wells are used during the hours mentioned above.

As to who uses this water we are not as sure for the following reasons. Jeffersonville is only 39 per cent metered, consuming 34 per cent of the water pumped during the year. The remaining 61 per cent is made up of flat rate consumers, consuming 66 per cent of the water pumped during the year. Of the water used through meters 20 per cent is used by industrials, and 14 per cent by domestics.

As I have shown above, for the various months of the year, it is apparent that our night demand is considerably higher during the winter months than it is during the summer. This we have readily accounted for, by the water wasted by consumers on flat rates. We find these consumers during cold weather very liberal in the use of water to save plumbers' bills and it is safe to say that at least 5 per cent of the average demand is made up in this way.

This we hope to overcome by the installation of meters throughout the city as soon as it can logically be done.

We have two railroads in the city who are also night consumers who take a fair percentage of this water. Certain manufacturers, especially two large manufacturers, carry a certain demand, the entire twenty-four hours of the day.

We find also from a study of the charts of the venturi meter that the demand materially increases about four o'clock in the morning. This we have reason to believe is brought about by the fact that a good portion of the Jeffersonville population is employed in Louisville with consequent early rising and the increased use of water.

We also know a certain part of this percentage is made up of loss through leakage in the distribution system, but just what the proportion is we are unable to ascertain at this time on account of the large percentage of flat rate consumers.

In New Albany, while the total consumption to this city is metered through a venturi meter at our stations, our meters are between the filtration plant and the clear well. Since delivery to the distribution system is by gravity, the variations in demand is taken care of in the basin, while the flow through the meter is constant, therefore no accurate method of getting an account of the night demand is possible. The average for the year approximates 25 per cent. This is higher than Jeffersonville, inasmuch as New Albany has several

large manufacturers who do seasonal business and one especially who, when operating during the winter months, uses large quantities of water through the entire twenty-four hours of the day.

New Albany is only 37 per cent metered, consuming however 55 per cent of the water pumped during the year, 20 per cent of this being by domestic and 35 per cent by industrial consumers. Sixty-three per cent of the city still remains on flat rate, who consume 45 per cent of the total water pumped during the year.

We have found by investigation and inspection that the waste of water by flat rate consumers is considerably less in New Albany than in Jeffersonville. However, we do not know what percentage of this is of the night demand, nor do we know what percentage of it is loss through leakage in the distribution system.

We are now working to the point where we may have accurate data, and that is 100 per cent meters to all consumers. When we have this condition we will be in a far better position to determine every phase of the consumption.

H. E. JORDAN:[5] This discussion has value in that it serves to call attention to waste and its prevention.

At the New Albany plant the lack of meters reflects itself in the increased winter night load, while at East Chicago increased demand due to wastage on cold nights has been practically eliminated.

The effect of meters in the latter community is striking. In 1920, the unit consumption was 234 gallons. In 1924, it has been reduced to 138. Assuming the same industrial demand, the domestic and commercial demand had been reduced from 154 to 58 gallons.

It is important to point out the erroneous idea that may be conveyed by reference to crude per capita figures. East Chicago, now 100 per cent metered, has a total rate, 138 gallons, that appears high until it is pointed out that actual sales to industrial users accounts for 80 gallons of this amount, and leaves the total of 58 gallons for all other uses.

This, if it has deducted from it the municipal uses, practically coincides with the rational demand of 40 to 50 gallons per capita.

[5] Sanitary Engineer, Water Company, Indianapolis, Ind.

THE CAUSES AND PREVENTION OF RED WATER[1]

By Paul C. Laux[2]

Red water is the term applied to water which is discolored with iron, either due to the presence of iron in the natural water or to the corrosion of the iron pipes with which the water comes into contact. Everyone is familiar with the iron stains on sanitary sinks and enameled bathroom fixtures, and this objectionable feature of the water, every good housewife will claim, is enough to condemn it unless the cause for the stains is removed.

If the red water is due to iron in the natural water only, then this is practically the only objection to it, and it can be corrected by one of the various iron removal plants. A water softening plant in the usual lime treatment of the water will remove the iron, as will also an aeration and filtration plant. Both systems depend on the oxidation of the soluble ferrous hydroxide to the insoluble, and therefore removable, ferric hydroxide.

When the natural water is free from iron and the water from the taps has the reddish color caused by iron, one meets a more serious problem, for here the trouble is due to pipe corrosion, and besides the staining qualities and unsightliness of the water, the life and the carrying capacity of the water mains are affected. Even though the corrosion goes on so slowly that its effect on the life of the pipes is not noticeable, it is bound, by its deposition of rust, to greatly reduce the carrying capacity of the pipes.

In a paper on Causes and Correction of Red Water by Thorndike Saville before the North Carolina Section of the American Water Works Association, last year, the speaker made this statement: "One may say that, when one-twenty-seventh the thickness of the wall of a 1½-inch iron pipe, or one-fortieth of the thickness of the wall of a 1-inch iron pipe is corroded the pipe is completely choked up." So, if it were unnecessary to prevent corrosion for any other reason, its effect on the carrying capacity of the pipes alone, would make a remedy compulsory.

[1] Presented before the Iowa Section meeting, December 2, 1925.

[2] National Lime Association, Chicago, Ill.

In order to understand just how corrosion takes place an elementary explanation of hydrogen ion concentration, or pH values, is necessary. Water dissociates very slightly into positive H ions and negative OH ions. The amount of these dissociated ions is very small. In pure water the amount of free hydrogen is 1 part of hydrogen to 10 million parts of water. The amount of free hydrogen in the water is called the hydrogen ion concentration, and this hydrogen ion concentration is expressed in terms of the pH value of the water. The concentration of hydrogen ions in distilled water is given a pH value of 7.0, based on the seven zeros in 10,000,000. If the water has a hydrogen ion concentration of 1 part of hydrogen to 100,000 parts of water, then the pH value would be 8.0, likewise a concentration of 1 part of hydrogen to 1,000,000 parts of water would give the water a concentration of a pH value of 6.0. Since pH 7.0 is the value of a pure water, this point is called neutral, and a water with a lower pH value is an acid water, because the presence of any acid radical will increase the amount of free hydrogen in the water, and a water with a higher pH value is an alkaline water, because any alkaline radical will decrease the ability of the hydrogen ions to dissociate. We might then define hydrogen ion concentration as the amount of hydrogen ions that are dissociated in the water, while pH value might be defined as an inverse expression of the hydrogen ions, based on the number of million parts of water necessary to produce one part of hydrogen. pH values below 7.0 indicate acid waters, while pH values above 7.0 indicate neutral waters.

This dissociation of water, or hydrogen ion concentration has a direct bearing on the corrosion which takes place in water mains, because the iron is very slightly soluble in water, the solubility depending on the dissociation of the water into hydrogen (H) ions and hydroxyl (OH) ions, so that the following reaction takes place:

(1)	Fe	plus	2HOH	equals	$Fe(OH)_2$	plus	2H
	iron		water		ferrous hydroxide		hydrogen

The hydrogen will form a film over the iron and prevent further corrosion, unless it is disturbed. Most water supplies, however, contain dissolved oxygen, which absorbs the hydrogen to form water, according to the following equation:

(2)	2H	plus	O	equals	HOH
	hydrogen		oxygen		water

This oxygen also oxidizes the ferrous hydroxide, as formed in equation one, which is soluble in water to the insoluble ferric hydroxide.

(3) $4Fe(OH)_2$ plus $2O$ plus $2H_2O$ equals $4Fe(OH)_3$
ferrous hydroxide; oxygen; water; ferric hydroxide

This ferric hydroxide, or rust, may be deposited on the surface of the pipe and prevent further corrosion. It is a rather unstable covering, however, and is more readily removed in acid waters than in alkaline waters. The reason for this is rather involved, but it again depends on the hydrogen ion concentration. As previously stated, the pH value of acid waters is low, therefore the amount of hydrogen ions is great. If the dissociation of the water is slow, as it is in alkaline or nearly neutral waters, it forms a film around the iron pipe or the corrosion, but if it is rapid, as in acid waters, then the hydrogen gas escapes, and the equilibrium of the reactions is broken, and since both hydrogen and iron are positive radicals, iron is required to replace the hydrogen.

The prime factors in corrosion, then, are hydrogen ion concentration and dissolved oxygen. However, we must not overlook the action of free carbon dioxide in the water, Most natural waters contain free carbon dioxide due to the decomposition of organic matter, and this amount is increased by the action of alum when it is used as a coagulant, as will be explained later. Where free carbon dioxide exists in the water, it unites with part of the water and forms a weak acid known as carbonic acid

(4) CO_2 plus HOH equals H_2CO_3
carbon dioxide; water; carbonic acid

It has already been stated that in an acid water the hydrogen ion concentration is greater than in a neutral or alkaline water, and corrosion increases with hydrogen ion concentration. It has also been brought out that the protective rust film formed is less stable in acid than in alkali waters, so that by causing acid conditions in the water, carbon dioxide has a twofold effect in increasing the rate of corrosion.

1. It increases the amount of ionized hydrogen in the water.
2. It weakens any protective coating of iron rust that may be formed.

Besides these two factors, however, carbon dioxide has another effect on corrosion. When it forms carbonic acid by uniting with water it adds a solvent for the iron according to the following equation:

(5) Fe (iron) plus H_2CO_3 (carbonic acid) equals $FeCO_3$ (iron carbonate) plus $2H$ (hydrogen)

This iron carbonate is then acted upon by dissolved oxygen in the water as follows:

(6) $4FeCO_3$ (iron carbonate) plus $2O$ (oxygen) plus $6H_2O$ (water) equals $4Fe(OH)_2$ (ferric hydroxide) plus $4CO_2$ (carbon dioxide)

It is to be seen, from this equation, that the carbon dioxide is again liberated and ready to start all over again with fresh iron from the pipe, so that a small amount of carbon dioxide will cause a considerable amount of corrosion.

Obviously then, when trouble exists due to corrosion, one thing to do is to get rid of the free carbon dioxide in the water. If the water is aerated, most of the carbon dioxide is removed, but the dissolved oxygen content is usually increased in this operation, adding to a condition which is in itself already corrosive. If an alkali, such as lime, is added to the water, the free carbon dioxide is absorbed, forming calcium bicarbonate, as follows:

(7) $Ca(OH)_2$ plus $2H_2CO_3$ equals $CaH_2(CO_3)_2$ plus $2HOH$

Soda, ash, caustic soda, or any other alkali would have the same effect as lime, but lime is the most economical remedy. J. W. Ledaux, in the Water Works Issue of Engineering and Contracting, January, 1925, states that $1.00 worth of lime is as effective as $3.27 worth of caustic soda, or $5.65 worth of soda ash.

The amount of carbon dioxide that must be removed varies with the nature of the water. At Baltimore, Md., this treatment is based entirely on pH control. The pH value aimed at is between 7.2 and 7.4. As lime is added the hydrogen ion concentration is reduced, due to an increase in the alkalinity, while the pH value is raised. Leeds and Northrup have installed there a potentiometer which records the pH value by means of colored lights. When a red light appears, the pH value is too low and the amount of lime

added is increased. In the same manner, when a blue light appears, the pH is higher than is necessary to prevent corrosion, and the lime dosage is decreased.

While it is generally accepted that carbon dioxide corrosion can be prevented by raising the pH value to a point above 7.0, still many waters high in carbonate hardness and therefore alkaline, may be corrosive due to an excessive amount of free CO_2, and a lime, or other basic treatment, is required to reduce this carbon dioxide content to a point below the aggressive. Every water brings its own individual problems and it is impossible to set a hard and fast rule as to the pH value or the amount of free carbon dioxide permissible without causing corrosion in all waters. However, if red water troubles due to corrosion exist, chances are that there is too much free carbon dioxide in the water, and the addition of an alkali will correct this condition.

Alkalinity exists in water as magnesium and calcium bicarbonates. The normal carbonates are insoluble in water, but since most natural waters contain free carbon dioxide, which forms carbonic acid, the normal carbonates are changed to bicarbonates according to the following equation.

(8) $CaCO_3$ (calcium carbonate) plus H_2CO_3 (carbonic acid) equals $CaH_2(CO_3)_2$ (calcium bicarbonate)

If lime is added to water containing calcium bicarbonate in excess of the amount required to absorb the free carbon dioxide present, then the following reaction takes place:

(9) $CaH_2(CO_3)_2$ (calcium bicarbonate) plus $Ca(OH)_2$ (calcium hydroxide) equals $2CaCO_3$ (calcium carbonate) plus 2HOH (water)

The normal carbonates, being insoluble, are deposited as a fine coat on the pipe and protect the iron from the water, and thus prevent corrosion. However, when this coat is formed, water with free carbon dioxide will again change this coat to the bicarbonate and remove it, the bicarbonate being soluble in water. Therefore, even if a protective coating is formed on the pipe, carbon dioxide removal is still necessary to protect the coating as well as the pipe.

Where to apply lime for correcting corrosive qualities of water is another problem. In some cases it is added directly with the alum,

i.e., ahead of the mixing and sedimentation. However, in some cases the water is of such nature that the lime will interfere with the coagulation, if added in this manner. A point in case is at Akron, Ohio. Here the lime was added, first ahead of mixing, then after mixing and ahead of sedimentation, next it was added ahead of the filters, but after sedimentation. There were objections to all of the points of application, and now the milk of lime is added to the clear well under a unit of five filters and is mixed with the water from twenty other filters in the conduits leading to the suction well, and in the suction well itself.

This treatment has eliminated all red water trouble and main corrosion, and has not given rise to any evils, such as after-deposits. According to Mr. Gettrust, the chemist in charge of the Akron plant, the only people not pleased with the water since this treatment was inaugurated, are the plumbers.

Another instance where lime is added to the water to absorb free carbon dioxide is at Hannibal, Mo. Here a new plant has been built and just recently put into operation. When I visited there, the plant had not been completed, but the plan of treatment was about as follows. The water was to be treated with sulphuric acid for color removal, and alum was to be used for coagulation. Both of these treatments increase the sulphate hardness of the water, and therefore must liberate free carbon dioxide, so that a lime treatment will be necessary to remove this water from the corrosive class. Mr. Wolf, the chemist, figures on adding the lime into the suction end of the pump which will lift the water from the filtered water reservoir into a storage reservoir of several million gallons capacity, from which the water will be distributed throughout the city mains. At Evansville, Ind., the lime is added just ahead of the filters, giving very good results, while at Baltimore, Md., the lime is added to the conduit leading from the filters to the clear well.

Surface waters that are used for city water supplies contain turbidity that must be coagulated before the water can be properly clarified by sedimentation and filtration. For this purpose alum is used in most instances. The action of alum, or aluminum sulphate depends on its changing from the sulphate form to aluminum hydroxide. In this process, part of the alkalinity or carbonate hardness of the water is changed to sulphate hardness, while the carbonate radicals are liberated as carbon dioxide. Thus in treat-

ing water with alum, the free carbon dioxide content, and therefore the corrosive tendency of the water is increased.

The carbon dioxide content of the water is measured by using phenolphthalein indicator. If the water gives even a very faint pink color when the indicator is added, then no free carbon dioxide is present. If, however, the water remains colorless upon the addition of a drop or two of N/50 sodium hydroxide, then free carbon dioxide is present and the amount of the sodium hydroxide required to give the water a pink color solution indicates the amount of free carbon dioxide in the water.

To see what the action of alum on free carbon dioxide content of water is, take a sample of water, add a few drops of phenol indicator, and sufficient N/50 sodium hydroxide to bring about a faint pink color in the water. The number of cubic centimeters of solution required to bring about this color change multiplied by 10 will indicate the parts per million of free carbon dioxide in the water. Now take another sample of the water and add to this sample several grains per gallon of alum, mix thoroughly and filter part of it and titrate in the same manner. The increase in the content of free carbon dioxide measures the amount of gas set free by the action of the alum on the carbonate hardness of the water.

To demonstrate that it is free carbon dioxide that has been absorbed until the pink color appears in the water, blow through a glass rod or pipette into the cylinder containing the colored water, first adding enough sodium hydroxide solution to bring about a deeper color, so that the change will be more distinctive. As one exhales through the tube, carbon dioxide is introduced into the water, and the pink color disappears.

This determination is based on the fact that normal carbonates are indicated by the phenol color in the water, when no normal carbonates are present, the water remains colorless. As sodium hydroxide is added to the water, it is changed by the free carbon dioxide to sodium bicarbonate. Just as soon as all of the carbon dioxide has been consumed, the bicarbonate will give up its excess radical or carbon dioxide to the sodium hydroxide and both will form normal carbonates, and the pink color will appear. Then as carbon dioxide is again added, the normal carbonates are changed to bicarbonates, and the color disappears.

It has already been pointed out that the addition of alum changes the bicarbonates to sulphates of calcium and magnesium. Pre-

sumably then it is possible to have a condition where the alkalinity is so low that not enough bicarbonates are present to react with the water. When aluminum sulphate is added to an alkaline water, the following reaction takes place.

(10)	$Al_2(SO_4)_3$	plus	$3CaH_2(CO_3)_2$	equals	$3CaSO_4$	plus	$2Al(OH)_3$	plus $3CO_2$
	aluminum sulphate		calcium bicarbonate		calcium sulphate		aluminum hydroxide	

Each grain of alum required to flocculate the turbidity in a water destroys about ½ grain per gallon of alkalinity in this manner. If insufficient alkalinity is present, the alum must hydrolize into sulphuric acid and aluminum hydroxide, which is a rather slow process and gives rise to slow and unsatisfactory coagulation. If lime is added in sufficient quantities to completely satisfy the alum by increasing the alkalinity, then better and quicker coagulation results. This action is shown in the following equation:

(11)	$3Ca(OH)_2$	plus	$Al_2(SO_4)_3$	equals	$2Al(OH)_3$	plus	$3\ CaSO_4$
	calcium hydroxide		aluminum sulphate		aluminum hydroxide		calcium sulphate

WATER SUPPLY CONDITIONS IN MISSOURI[1]

By George W. Putnam[2]

Water supply conditions in Missouri are perhaps the most varied of any middle western state, owing to the pronounced differences in topography and geological formations. Portions of the state are located in three distinct physiographic divisions. The Missouri River flowing from west to east roughly bisects the State. The north half, together with two areas south of the River, is situated in what geographers have classified as the Interior Plains of the United States. (See figure 1.) Illinois, Iowa, South Dakota, Nebraska and Kansas are also situated in this physiographic division. Owing to the highly mineralized character of much of the ground water obtained in this section of Missouri, the majority of the cities obtain their water from surface sources, including rivers, streams and impounding reservoirs.

The extreme southeast portion of the State is situated in what is termed the Atlantic Coastal Plain. This section formerly contained considerable swamp land which has been drained and planted extensively in cotton, giving excellent yields. Cities in this section obtain their water supply from wells. The majority of these penetrate only the upper stratum of sand and gravel and are of comparatively shallow depth.

The portion of the State south of the Missouri River, with the three subtractions above noted, is situated in the division known as the Ozark Plateaus. Cities in this section obtain their water supply principally from deep wells drilled in rock. A few are obtained from springs and mines. Some of the largest springs and caves in the United States are located in this district.

SURFACE WATER SUPPLIES

Considering first the surface water supplies, we naturally find that the seven cities over 15,000 population, namely, St. Louis,

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Chief Sanitary Engineer, State Board of Health of Missouri, Jefferson City, Mo.

Kansas City, St. Joseph, Joplin, Springfield, Hannibal, and Sedalia, are using surface water, being compelled to do so to secure the necessary volume economically. Fourteen out of twenty-two cities from 5000 to 15,000 population are also supplied with surface water. The striking feature is the fact that fifty-two cities under 5000, out of the 171 having water supplies, are compelled to use a surface water supply from streams or impounding reservoirs. With five exceptions all of these towns are located in the Plains district, the reason being,

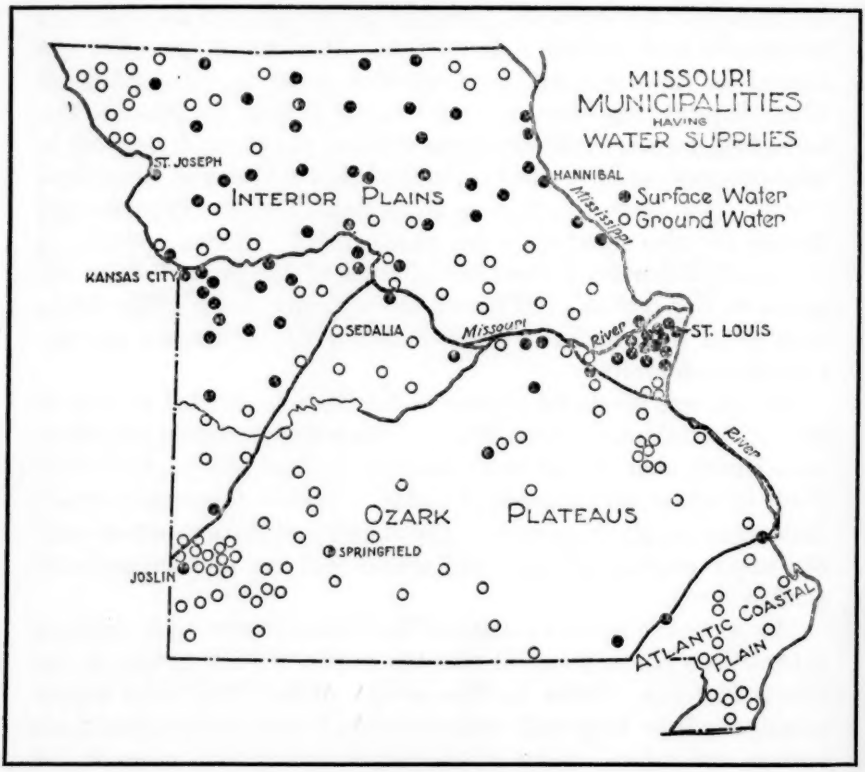

FIG. 1

as mentioned before, that most of the well water in this district is so highly mineralized that it does not constitute an acceptable domestic supply. Where a city of 2000 population in the Ozark section can secure a deep well supply for $5000 to $10,000 outlay, a north Missouri city in the Plains district is usually compelled to spend from $30,000 to $60,000, to obtain a surface water supply from an impounding reservoir or stream, and to provide a filtration plant to purify it.

Several cities in the Plains district, as for example, Clinton, Edina, Holden and Higginsville, within the past three years have abandoned a highly mineralized well supply, containing hydrogen sulphide gas and excessive hardness and have provided a soft filtered water of low mineral content from a surface source.

Twenty-nine cities are supplied with purified water from the Missouri and Mississippi Rivers. The pollution of these rivers is considerable, as is evidenced by the fact that the Missouri River water at the Kansas City intake contains an average of about 6800 B. coli per 100 cc.; the Mississippi River water at Quincy, 1700; and the raw water from both rivers at St. Louis, 3700. It will be noted that these B. coli counts are materially in excess of the limit for safe loading of filter plants without chlorination, namely, 650 per 100 cc., suggested by H. W. Streeter, Sanitary Engineer of the United States Public Health Service. This suggests the possible necessity in the future of a comprehensive sewage treatment program for the cities on these rivers in Missouri and other states upstream to lessen, or at least to prevent, an increase in the pollution load on water plants obtaining their supply from these rivers.

Of the sixty-six surface water plants in the State, thirty-six have complete filtration plants; four are complete except for chlorination; eleven have coagulation, settling and chlorination; and fifteen have either less complete or no purification. No great difficulty has been experienced in purifying surface waters in Missouri, with the aid of final chlorination, accurately controlled with the o-tolidine or similar test for free chlorine, so that the finished water will conform to the Treasury Department Standard for safe drinking water.

The past few years has developed considerable activity in enlarging and improving the water purification plants in the State. Filtration plants have been completed in the last four years in Canton, Clinton, Edina, Flat River, Glasgow, Hamilton, Hannibal, Higginsville, Holden, Kirksville, Milan, Moberly, and Trenton. Other major improvements to surface water supplies have been completed in recent years at Cameron, Chillicothe, King City, Paris, Shelbina, Springfield and Valley Park. New filtration plants are now under construction in St. Louis, Kansas City, Jefferson City and LaPlata. Extensive improvements are being made at Sedalia.

The need of an organization of waterworks men having charge of purification plants in the State has been evident. On October 26–27 of this year, the State Board of Health called the first Missouri

Conference on Water Purification. The meeting was well attended and a lively interest was shown in the papers and discussions. A permanent organization was formed to hold an annual conference meeting and to serve as a clearing house for information of benefit to the members.

The importance of careful operation of water purification units has been forcibly demonstrated twice in Missouri, since the sanitary engineering service was established in 1922 by the State Board of Health. In February, 1923, the railroad drew heavily upon the local waterworks at Louisiana, so that the rate of filtration one day had to be increased some 50 per cent. The chlorine dosage was not increased, or a proper test for residual chlorine maintained, and the following day a widespread epidemic of diarrhoea occurred. The water is obtained from the Mississippi River and the pollution load is considerably in excess of the suggested safe loading limit mentioned above for filtration alone.

Pierce City recently voted bonds for the installation of a deep well to permit abandonment of the existing contaminated spring supply. However, this wise provision for the future did not protect the existing supply, and when laxity in keeping the chlorinator in continuous operation recently occurred, an epidemic of twenty-two cases of typhoid with two deaths followed.

GROUND WATER SUPPLIES

One hundred and nineteen of the 185 water supplies, or approximately 65 per cent, are secured from ground water sources. The majority of these supplies are obtained from deep wells drilled in rock. This water is from either limestone or sandstone and is moderately hard, but always of acceptable physical and chemical quality when obtained in the Ozark district. Those supplies obtained from shallow wells in sand or gravel strata usually contain excessive quantities of carbon dioxide gas and iron. Supplies of this character are treated successfully in iron removal plants at Caruthersville, Excelsior Springs, Kirkwood and Liberty. A fifth plant is now being installed at Salisbury.

Ground water supplies are also obtained in a few instances from springs, mines and infiltration galleries. All surface spring supplies used by municipalities are contaminated at intervals with surface water and require treatment. Five municipalities are supplied with water from lead mines in St. Francois County, the largest lead produc-

ing mining field in the world. One supply is from a spring in a mine. This water is of excellent sanitary quality and is used without treatment. The other supplies are furnished with mine water, draining mainly from working levels, purified by filtration and chlorination. The ore occurs in the form of galena which is a sulphide of lead and is insoluble in the water. There have never been any cases of lead poisoning among the miners or among residents drinking the water.

SANITARY PROTECTION OF GROUND WATER SUPPLIES

Experience in Missouri indicates that there are many sanitary defects in connection with ground water supplies which have in the past caused the intermittent infection of otherwise safe supplies, and that many municipalities have had a false sense of security regarding the safety of their supplies, due to the popular idea that all ground water has received complete natural purification. As a matter of fact there are records of more epidemics occurring on ground water supplies in the State in the past than on surface water supplies. Underground pollution of wells and springs with surface water takes place through the fissured, shattered limestone strata of the Ozark section unless carefully guarded against. A striking example of the open character of the limestone strata in many portions of southern Missouri is illustrated in the case of the Springfield water supply. The main source of supply is a large spring located at the base of a hill. Water of recent surface origin gains access to the spring through sink holes and fissures in the outcroppings, and for this reason a complete filtration plant has been provided for purification. The flow of this spring is not sufficient at some periods of the year, and the supply is supplemented by water from either deep wells or from a 125,000,000 gallon impounding reservoir, which is located four miles from the spring. The unusual point is that no pipe line connects the reservoir to the purification plant. A pipe carries the water only a quarter of a mile below the impounding reservoir, where it discharges into an opening in the limestone, and the water travels underground through solution channels in the rock to the main spring, taking from four to six hours for the journey.

A careful study of the sanitary defects permitting the contamination of ground water supplies in Missouri has been made by the State Board of Health and the necessary safeguards established. This information was incorporated in a comprehensive detailed report of the Committee of the Conference of State Sanitary Engineers on

Sanitary Control in the Development of Ground Water Supplies, adopted at their 1925 meeting in Louisville, Ky.

In the case of deep wells drilled in rock, and particularly in the fissured limestone strata, the recommended specifications of the State Board of Health (see appendix A) require the casing extended and sealed below all openings or soft or broken ground. Samples of each screw are saved by the driller and submitted to the State Geologist, together with a carefully kept log of the well, in order to insure that the casing is extended deep enough to shut off all surface contamination. Bacteriological examinations even reveal a few instances in which properly constructed wells of considerable depth are located in such deeply fissured rock that contamination reaches them. In these instances purification is adopted. An old city well at Monett tapped an underground lake, the water in which became turbid after rains. In 1914, a devastating typhoid epidemic resulted. Now, they have three wells in a fairly solid formation, but chlorinate all the water as a factor of safety.

GENERAL DATA

The total number of incorporated municipalities in Missouri supplied with water from public water supplies totals 200. In some instances two or more municipalities are supplied from a single source. In addition, there are two supplies furnishing water to unincorporated districts alone, so that the actual number of public water supplies in Missouri totals 185. The number, and percentage of total number, of cities in various population groups having water supplies in Missouri is given below:

	OVER 2500	1000–2500	UNDER 1000
Total number cities in class	65	118	530
Number having water supplies	65	87	48
Percentage having water supplies	100%	74%	9%

It will be seen that, in common with her neighboring states, Iowa and Kansas, Missouri has no towns over 2500 without waterworks.

With reference to fire protection, the Missouri Inspection Bureau, representing the fire insurance underwriters, have rated 166 of the incorporated municipalities having public water supplies. The number of towns in the different ratings, as tabulated by this Bureau, are given below:

Missouri Standard—Class	1½	2	2½	3	3½	4	4½	5
Number of cities in class	1	1	1	1	8	19	98	37

In explanation of the large number of towns occurring in the 4½ and 5th class, it might be explained that the 4½ class is about the highest that it appears economically feasible for the smaller cities under 5000 population to maintain at the present time.

Many municipalities in Missouri under 2500 population are greatly in need of public water supplies for fire protection and convenience purposes. In the majority of these cities, there is also a pressing need for a safe municipal water supply for sanitary reasons, as shallow wells or cisterns are generally contaminated with surface, shallow ground water, and waste water from the pumps. The studies and experience of the State Board of Health on epidemics have convinced them that a safe public water supply is a paying investment to the average city from a health point of view alone. In 1921, Potosi, a town of 1000 population, suffered from a water and filth-borne typhoid epidemic which resulted in fourteen deaths. Fourteen lives at $5000 each totals $70,000 economic loss in a single year. This exceeds the cost of a waterworks system to serve the town.

The State Board of Health is lending active encouragement to the installation of new waterworks and sewerage systems through sanitary surveys, analyses of private water supplies, and educational talks given at mass meetings of citizens or civic organizations. In the past three years, twenty-two towns have installed new waterworks and forty-seven have made necessary sanitary improvements thereto.

The bounding limit for cities under 30,000 has been successively increased from 5 to 10 per cent of the assessed valuation, and then to 15 per cent in 1920. The bonded indebtedness for sewers and other city debt must not exceed 5 per cent, leaving 10 per cent for waterworks, electric light, and ice plant, in case 5 per cent has already been voted for sewers or other city debt.

One difficulty in securing the installation of waterworks systems is that a bond issue must have a two-thirds majority of all those voting. While this seems quite a barrier to clear at the start, most cities, when the bond issue has been defeated at the first election, have passed it by good majorities at the second election by thoroughly organizing their campaign to get out the favorable votes. The average majority vote of those bond issues carried in the past two years has been over seven to one. In 1923, Festus, population 3348, rolled up the nearly unanimous majority vote of fifty-five to one, for a bond issue of $175,000 for complete waterworks and sewer-

age systems. This was accomplished by a spirited citizen's campaign, in which the State Board of Health coöperated.

SUMMARY

In conclusion, water supply conditions in Missouri are quite varied owing to topographical and geological differences within the State. An unusually large percentage of the municipalities are supplied from surface sources, particularly among the smaller cities owing to the highly mineralized character of the ground water in the Plains district of the State. Ground water supplies obtained from fissured limestone in the Ozark district must be carefully safeguarded to prevent their contamination with surface water, or adequately purified. Real progress is being made in establishing new water supplies in the smaller cities, in securing essential improvements to existing supplies, and in improved operation of water purification plants.

APPENDIX A

State Board of Health of Missouri

RECOMMENDED SPECIFICATIONS ON SANITARY PROTECTION FOR WELLS DRILLED IN ROCK

1. At least one week before starting to drill the well, the driller shall send a written request to the State Geologist, Rolla, Missouri, who will furnish a set of small sacks and a drill record book, and advise the depth of casing advisable to effectively shut out contaminated surface water from the well, based upon available records.

2. The well driller shall save a sample of cuttings from every screw and place same in the sacks properly labeling same. The driller shall note in the drill record book the location and depth of any openings or soft or broken ground.

3. When the well has been drilled to a depth equal to that of the recommended depth of casing, the driller, when requested, shall forward the samples of cuttings and record book to the State Geologist for examination.

4. The well shall be cased with a screw joint steel or wrought iron pipe installed in a watertight manner. This casing shall be extended past all openings or soft or broken ground and at least 10 feet into solid rock.

5. A satisfactory seal shall be made or installed at the bottom of the casing, by one of the following methods:

a. Setting bottom of casing in drill cuttings of a cementing character on a shoulder in the well made by reducing the size of the drill hole.

b. Driving casing into clay, shale or similar sealing formation.

c. Cement grout.

d. Lead packer.

e. Expanding rubber packer.

The seal shall be tested by bailing out the drill hole and making sure that there is no leakage into same over a period of forty-eight hours. When no appreciable amount of water has been encountered up to time of sealing, at least 1000 gallons of water, or as much as can be, shall be run into the annular space on the outside of the casing to test the seal.

Complete information on the depth of casing, method of sealing same, and result of test of seal shall be written in the drill record book.

6. The well casing shall be extended to a point from four to six inches above the elevation of the finished pump room or pump pit floor, and shall be provided with a thread at the top.

7. On completion of the well, the driller shall forward all samples of cuttings and the drill record book to the State Geologist, who will correlate same and furnish the owner with a copy of the completed log of the well.

WATER BUREAU INTERESTS DURING THE CONSTRUCTION OF THE NORTH BROAD STREET SUBWAY, PHILADEPHIA[1]

By S. M. Van Loan[2]

A monumental structure within the limits of a city or in any congested area will impose numerous inconveniences upon persons or interests located within the construction area. Protests from a minority must be met in a courteous way, but progress must not be stopped and often the areas involved by the activities experience hardships.

The Bureau of Water has been the recipient of many complaints where a distribution of water is modified or adjusted. A reduction of pressure, a suspension of service and a taste or odor, the latter imagined or not, have been mainly the type of protests registered in the department. On one occasion the failure of a large main deposited such a volume of water in a freshly excavated section of the subway work that sustaining embankment back of sheeting gave way, but early attention corrected this loss of support and normal conditions were soon restored.

To visualize the water distribution system and its relation to Broad Street where the present work on subway construction is active, it is in order to digress from the main subject and outline briefly a history covering location and water lines involved.

An early means of furnishing water to Philadelphia was through a pumping station located and built during the year 1799 on the Schuylkill River at Chestnut Street. Here an engine of 1½ m.g. capacity pumped through a circular brick conduit built on Chestnut Street to Centre Square on which now stands the Public Buildings—City Hall—at Broad and Market Streets. The latter building, with a pumping installation of 1 m.g. capacity, was erected on Centre Square in 1801 and was removed during 1829 at which time a supply of water was being furnished from the Fairmount Works.

[1] Presented before the 4-State Section meeting, December 17, 1925.

[2] Assistant Chief Engineer, Bureau of Water, Philadelphia, Pa.

The construction of the subway under the existing City Hall uncovered sections of the masonry flume referred to above and excavations on Chestnut Street have at times involved this old structure.

Following the Fairmount Works there were built in 1848 those located at Girard Avenue, called the Spring Garden Works. From both were pipe lines conveying water to reservoirs and from the latter 48, 36- and 30-inch mains were laid to furnish with a supply of water the rapidly growing city.

A glance at the map of Philadelphia will disclose Broad Street, the location of which marks closely a midway line between the Schuylkill and Delaware Rivers—for a length of approximately seven miles. Further observation shows the street system developed with those two main thoroughfares forming somewhat a means for transit and utility convenience.

Market Street being laid out at an earlier date has borne cars on its surface from and including the horse drawn period to date, but a recognition of Broad Street as an attractive avenue for vehicles has kept it generally clear from surface or elevated common carriers.

Approaching the year 1900 the largest water pipe occupying Broad Street was 30 inches in size. A number of smaller mains were laid for the consumers' service and due to the roadway width these were placed on each side, but not under the footways.

With the construction of the filtration system a radical change was planned for the supply of water east of the Schuylkill River. An impressive addition to the water works included a large filter plant at Torresdale with an imposing pumping station at Lardner's Point from which Delaware River water would be delivered through an extensive pipe system for express and service purpose. The existing mains had been designed to distribute a supply of water pumped from the Schuylkill and much of this system continued to function as trunks for the passage of water from the Delaware source, all of which made necessary a reverse flow through the mains. Such a design for a distribution system was far from ideal and considerable distortion was practiced to effect a flexible system. The filtration planning contributed to Broad Street a 48-inch trunk main and upon the water introduction to the new design, the distribution system was functioning with a draft of 65 and 35 per cent respectively from the Delaware and Schuylkill Rivers. During the last two decades a pipe system for fire fighting purposes was added throughout a considerable length of this same street. This main is 12 and 20 inches

in size and with the connecting fire hydrant lines contributed an additional structure to maintain.

The studies on subway construction offered the Bureau of Water the opportunity to iron out some of the pipe installations which had resulted from a time-to-time addition, a record of such connections being only in the minds of former employees.

Generally a policy was adopted to remove and relocate the large mains lying parallel with the longitudinal axis of Broad Street and to raise those of the important trunks which were on intersecting streets. An early policy adopted on one contract held to hanging the service mains from the deck of the timber bridge which formed the vehicular surface. The vibration due to the passage of trucks and cars and the shock imposed by the use of dynamite caused innumerable breaks which became a general nuisance to the contractor excavating below decks and likewise the loss of water to the householder and business plant raised a storm of protests. A general laying of new pipe was resorted to in a location adopted under the footway and the new line was charged before the services were transferred. This method of operation was extremely satisfactory and much confusion was eliminated. On such sections where large mains were crowded out a parallel street was selected to provide a location for new pipe. A section of the work through a congested area will not admit of this transfer and it is purposed to relay a 48-inch main over the masonry roof of subway—reducing at station locations to twin 36-inch mains.

The high pressure fire lines were moved to a location generally under the footway, requiring also the relocation of many fire hydrants. No breaks have occurred on this system of piping and during subway construction the line has been supported on 12 × 12 posts.

One break of a serious nature has occurred on large pipe, where active work was under way on a 48-inch crossing Broad Street, the location of which required a radical adjustment to permit the passage of the subway. The break took place at an hour when workmen were few and the subsurface supports took splendid care of the flood.

The raising of a section of 48-inch steel pipe marked an unique piece of work. The elevation of this pipe was low for the subway section which in turn could assume no lower level due to the existence of a trunk sewer over which it must pass. During the activities of the existing contracts there have been involved 26,000 lineal feet of 48,

36- and 30-inch pipe together with 64,000 lineal feet of 12-inch and smaller, all of which construction has been executed by the contractors' force under expert inspection.

The Water Bureau assigned selected men to handle valves in case of trouble and a most harmonious coördination with the construction interests has been in effect. Where lines were relaid holding to equal sizes, the expense of pipe and laying was borne exclusively by the Transit Department. In the event of a larger main being planned such as the service mains which were formerly six inch, the Bureau of Water met the difference in cost. Pipe of all descriptions have been encountered: bored wooden logs laid prior to 1820 and cast iron pipe brought from England, some of which were imported as early as 1817. The following were the domestic contributions of cast iron bell and spigot; cast iron flange; cast iron universal and steel. The handling of each and all has placed no unusual burden on the Department's force and many times during this construction incidents have happened which have injected a humorous cast to the outsider looking on. There might be reference to the consumer, even though notified, who, finding no water in his fixtures, due to a shift of service, left home and upon returning discovered a modest flood; there might be reference to the general protest along certain sections, of unskillful operation of the city's filter plant and the careless use of chemicals which gave an odor and taste to their water; and reference might also be made to the consumer who has suffered a loss of service due to the sawing off and appropriation by persons unknown of the temporary lead services exposed, but hidden below decks. All were insignificant occurrences to us in general, but of extreme moment to the individual or interests involved.

The informal and modest reference to this work is in no way intended to minimize its importance and problems have been met and solved and more are to be encountered. Similar planning for the provision of water service has been affected for a continuation of the subway to the south of City Hall.

No large work can proceed with any satisfactory progress without skillful management and coördination of interests concerned and the writer takes great pleasure in referring to the splendid way in which the contractors have executed their work and the generous way all concerned have contributed their efforts.

CHLOROPHENOL-LIKE TASTES IN BAY CITY'S FILTERED WATER SUPPLY

By Louis B. Harrison[1]

An understanding of the underlying factors which cause the chlorophenol-like tastes in the Bay City water supply, requires a short historical account.

During the year 1916, Bay City was supplied with water by two separate pumping stations, one pumping water from the Saginaw River and supplying the east side, and the other from the Saginaw Bay supplying the west side.

Owing to the constant outbreaks of typhoid fever, the City Water Department resorted in 1916 to liquid chlorination as a safeguard against water borne diseases.

Along the latter part of the fall of 1916, peculiar chemical tastes appeared in the water supply. The consumers, knowing that the water was being treated with chlorine, blamed this chemical for the tastes. The same year, during the winter months, fishermen reported that the fish were dying in the Saginaw River and Bay by the thousand, and that the fish had a peculiar chemical taste.

To locate the source of the trouble, samples of water were collected from different points along the Saginaw River and Saginaw Bay. All raw water samples collected at that time had a distinct phenol-like, or medicinal, taste.

Figure 1 will show the number of streams which empty into the Saginaw River. All industrial wastes and sewage from the different cities located along these streams are eventually dumped into the Saginaw River, which in turn empties into Saginaw Bay.

The Dow Chemical Company is located in Midland on the Tittabawassee River, a tributary of the Saginaw River. All samples collected in 1916 above the Dow Plant did not have the peculiar chemical taste, whereas all those below the plant had a very pronounced taste. It was then thought that the wastes from the chlorobenzol plants, where the Dow Company manufactured di-chloro-

[1] Chief Chemist, Water Department, Bay City, Michigan.

benzol in large quantities for war purposes, were responsible for these tastes and the killing of fish. Owing to war time conditions it was impossible immediately to stop the Dow Company from dumping that waste. However, since 1916, the Dow Chemical Company has been burning all the waste products from the chlorobenzol plants, and still the tastes persisted in the city water during the fall of the succeeding years, although the complaints from the fishermen decreased.

During the fall of the year a great deal of waste from the sugar plants along the Saginaw River and its tributaries is discharged into the river. These wastes are highly alkaline in reaction and rich in organic matter. As a result the dissolved oxygen is greatly depleted in the river during the sugar campaigns. Since these phenol-like tastes periodically recur during the sugar campaigns, the sugar factories were greatly suspected in being partially responsible for these tastes.

In 1920, the people of Bay City voted for a new water works including a filtration plant and new intake. The new intake pipe extends 4200 feet out in the Bay due north. The filtration plant was put into operation in June, 1925. With the exception of occasional musty tastes during September, the filter effluent was good. However, this did not last very long, for on November 4, 1925, chlorophenol-like tastes appeared in the chlorinated water. These tastes lasted for four days. The people went up in arms, and naturally blamed the chemicals used in filtration, as the cause of these tastes. Indignation ran high. Consumers of water called up the office quite provoked, and told us that we had some "nerve" in feeding them with carbolic acid, medicine, or chlorine. To establish definitely the sources of contamination it became necessary to collect samples of water, not only from the Saginaw River and Bay, but also from its tributaries.

As these tastes occurred several weeks after the sugar campaigns had started, I commenced to investigate the wastes from the various sugar plants. We collected samples of Steffen's waste, battery water waste, wash water waste, etc. and after combining these wastes and diluting them I chlorinated the same, producing a residual chlorine of 0.2 p.p.m. which is the amount present in our water when it leaves the high service pumps. I have tried chlorination of the mixed wastes before filtration and after filtration, and have not succeeded in producing a taste similar to the one we were getting in the chlorinated water.

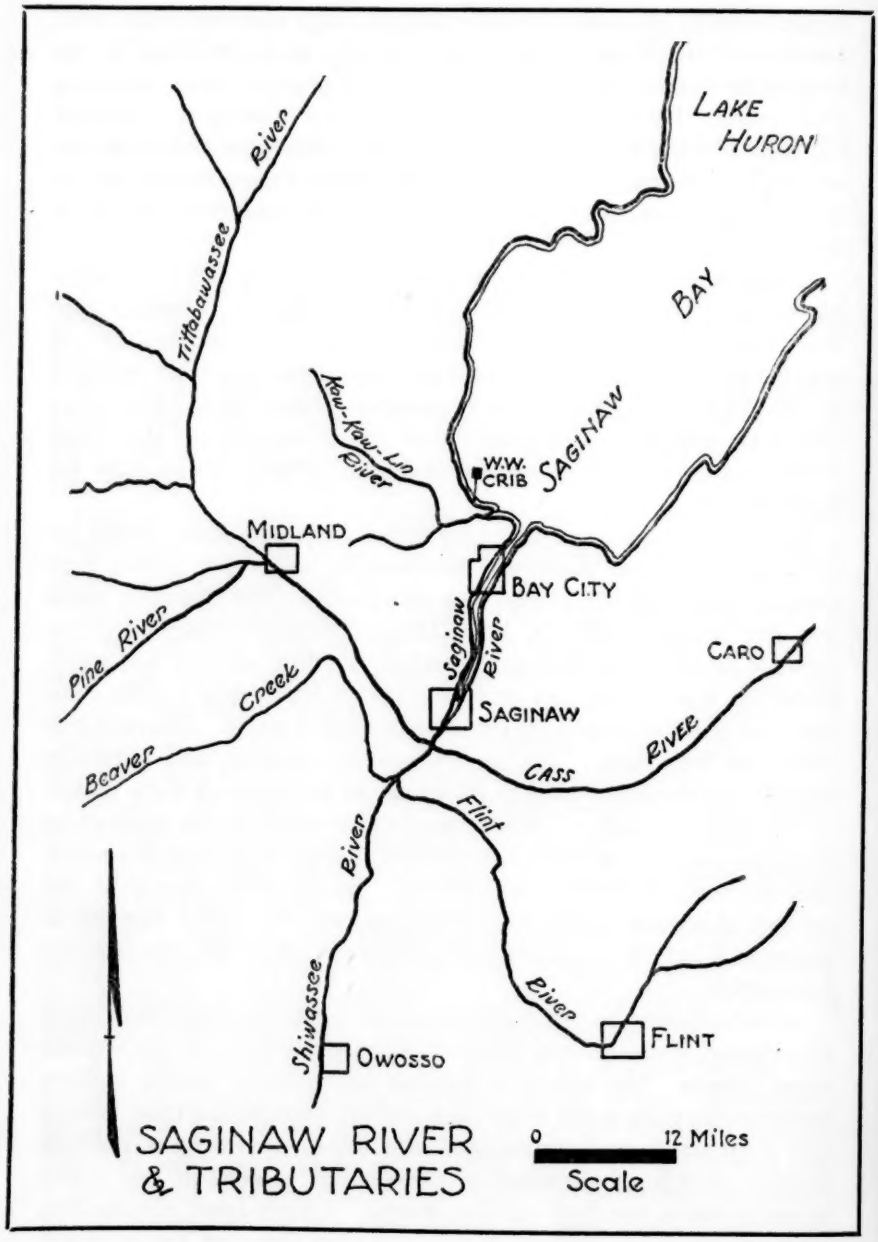
LAKE HURON
BAY
SAGINAW
W.W. CRIB
Kaw-Kaw-Lin River
Tittabawassee River
MIDLAND
BAY CITY
Saginaw River
Pine River
Beaver Creek
SAGINAW
CARO
CASS RIVER
Flint River
Shiawassee River
Owosso
FLINT
SAGINAW RIVER & TRIBUTARIES
0 12 Miles
Scale

FIG. 1.

Convinced that the wastes from the sugar plants were not directly responsible for these tastes, I directed my attention to different sources, and observed that whenever we get a southeast or northeast wind the river water is carried over to our intake. This we detect at the plant by a sudden rise in alkalinity and an increase in oxygen consumed. The chlorophenol-like tastes invariably make their appearance after such winds. The coincidence of the tastes with the change in the direction of the wind, satisfied me that these tastes are caused by some chemical in solution in the river water.

Inasmuch as the Dow Chemical Company was dumping chlorobenzol wastes into the Tittabawassee in 1916, we got busy and started to investigate conditions along the Tittabawassee River above and below the Dow Chemical Plant. Samples of water above the Dow Chemical Plant did not have these tastes, whereas those below did. I got in touch with the officers of the Dow Chemical Company and explained the situation to them. Owing to the fact that they were burning all wastes from the chlorobenzol plants they could not see how they could be responsible. It was necessary then to find what particular waste from the plant, if any, was responsible for it. Samples of wastes from the different organic plants were collected, diluted and chlorinated. The wastes from the phenol plants, when chlorinated, had a much more pronounced taste, and similar to the one in our city chlorinated water. The officers of the Dow Chemical Company were very courteous, and while they expressed doubts as to their responsibility in the matter, got busy at once and built a separate disposal system for all the wastes from the phenol plants.

After having established the fact by experimentation that wastes of a phenolic origin in great dilution when chlorinated, were responsible for these particular tastes, I extended the investigations to suspicious waste from other plants along the Saginaw River.

On December 5, 1925, after a strong south east wind, the tastes reappeared in the chlorinated filtered water with an exceptional intensity and lasted for ten days. It appeared to me that some one had dumped a large quantity of phenol wastes into the river. Hence, in addition to collecting samples of wastes from all possibly responsible industries, I interviewed some of the officers. Besides the wastes from the Dow Chemical Company in Midland, the wastes of the Consumers Power Company's gas plant at Zilwaukee on the Saginaw River and the E. I. Du Pont de Nemours Company's wood distillation plant showed the presence of phenolic products. From

my interview with the officers of the gas works, I have learned that during the latter part of the months of October and November they ran short in tank cars for their ammonia liquor and unintentionally let the ammonia liquor flow directly into the river. While I am not positive whether these dumpings, in particular during the latter part of November, were entirely responsible for the tastes, they undoubtedly helped to produce the extreme intensity, as this ammonia liquor contains a considerable amount of phenol. We got in touch with the officers of the Consumers Power Company, and they got busy to prevent the wastes from the ammonia still from getting into the stream.

The Dow Chemical Company, to prevent the phenolic wastes from going into the stream, constructed an intercepting sewer for all suspicious wastes from the organic plants. All these wastes are conveyed to a natural pond of immense size and about three quarters of a mile away from the river. Leaving out the factors of percolation and evaporation, it will take over two years for this pond to overflow. If it ever overflows, it will reach another natural pond of such size that it will take about ten years before it will ever overflow. The possibilities are that the second basin will never be used, as evaporation and percolation through the sandy soil will take care of all these wastes. The Consumers Power Company at Zilwaukee built a settling basin into which all the ammonia still wastes are discharged. From this basin, after the lime settles out, the fluid is pumped to the quenching tank and is used for quenching coke. While writing this paper, the E. I. Du Pont de Nemours Company has done nothing to stop their wastes from going into the stream, and as long as any phenolic waste is being dumped into the stream these tastes may reappear.

Performing experiments at the laboratory on the different wastes, I have noticed that all samples collected below the Dow Chemical Plant had a distinct chlorophenol taste before chlorination, whereas the wastes from the gas works and E. I. Du Pont de Nemours Company required chlorination. However, after some research I have discovered that the wastes from the Dow Plants carried a considerable amount of free chlorine in solution, and this chlorine in combination with the phenol wastes produced the taste. In the wastes from the gas works and E. I. Du Pont de Nemours I have been able to detect the tastes after chlorination in dilutions as high as one in two millions.

The reason why these tastes make their appearance during the latter part of the fall may possibly be attributed to the lower temperature and excessive organic polution from sugar plants. During the summer a vigorous bacterial action goes on in the Saginaw River, and probably these bacteria also decompose the phenolic wastes. On the other hand, late in the fall when the temperature of the water is close to zero, and dissolved oxygen is reduced by the sugar wastes, bacterial action is greatly reduced and the decomposition of phenolic wastes is lessened.

This paper would not be complete without expressing my appreciation for the assistance offered in this work by W. E. Baumgardner, City Manager, J. Crampton, Supt. of Water Works and B. B. Savage, Assistant Chemist.

Jesse H. Purdy

Died February 16, 1926

J. H. Purdy, Dean of water works managers and operators and one of the twelve honorary members of the American Water Works Association, passed away in the seventy-seventh year of his age at the St. Francis Hospital, Pittsburgh, Pa., after an illness of some weeks.

For forty-two years Mr. Purdy had been associated with the water works business and at the time of his death was Senior Vice President of the American Water Works & Electric Co., Inc. Perhaps no one man was more widely known or highly respected among operators of water works properties than Mr. Purdy. Though not an engineer by training his knowledge of operation and construction of water works plants was profound, a fact to which many well constructed and efficient operating properties throughout the country will always bear witness.

Mr. Purdy's connection with the water works business began in 1884, when he was a councilman in the City of Connellsville Pa. At this time a group of business men headed by Mr. W. S. Kuhn, approached the City Council for permission to build a water works plant in that city. Mr. Kuhn was so impressed with Mr. Purdy's abilities that he persuaded him to resign from his position on the Council and take over the active construction of the new water company.

This marked the beginning of Mr. Purdy's connection with the water works industry and the American Water Works & Guarantee Co., the predecessor of the American Water Works & Electric Co., Inc., which companies he served for almost half a century. After the completion of the Connellsville plant, Mr. Purdy obtained the franchises for and supervised the construction of numerous other water companies. For thirty years he was thus actively engaged. The water works plants at Huntington, W. Va.; East St. Louis, Ill.; Kokomo, Ind., and many others will always be tributes to Mr. Purdy's skill and foresight.

When Mr. Purdy became connected with the water works business, operating methods were primitive considered in the light of modern conditions. Always among the first to adopt improvements and refinements in service, Mr. Purdy, during his many years of active service, was active in the development of filtration, chlorination, softening and other processes, which have brought comfort and health into the homes of millions.

Mr. Purdy installed filtration plants at Chattanooga, Tenn., and Little Rock, Ark., prior to 1890, these being two of the earliest successful filtration systems constructed in the United States.

Successful as a business man and a leader in his field, it is another side of Mr. Purdy's character that will be remembered by his friends and associates. Kind and helpful, he always gave of himself. He had the rare gift of bringing harmony and team work to any organization with which he was connected. Mr. Purdy exercised a tremendous influence for good on the lives of his associates—especially the younger men. No one came into contact with him without feeling better for it and there was no conscious effort on his part toward this end.

Besides being an honorary member of the American Water Works Association, which he joined in 1896, Mr. Purdy was one of the founders and a past President of the Pennsylvania Water Works Association. He was associated with other prominent business men in founding Kingsley House, one of the largest welfare organizations in the City of Pittsburgh.

Mr. Purdy leaves behind him to his many friends, a memory of an upright man, who did right, and loved his fellows. There can be no better memorial.

H. Hobart Porter,
George W. Biggs, Jr.,
George W. Fuller.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Fourth Annual Report of Ohio Conference on Water Purification, November, 1924. 1925, 99 pp. The miscellaneous topics discussed included relative value of lactose broth and bile for detection of B. coli, number of dilutions required for calculating B. coli content, and employment of superchlorination and dechlorination with sulfur dioxide as means of eliminating certain gas-forming organisms which are resistant to normal doses of chlorine. It was reported that substitution of pebble quicklime for hydrated lime at Columbus and Delaware plants had proven satisfactory and had effected considerable economy in operating costs. **Offensive Tastes in Public Water Supplies Caused by Industrial Wastes.** W. H. DITTOE. Ibid., 7–10. Prevalence of taste and odor due to phenol-containing wastes and progress in prevention of same are reviewed and discussed, and it is pointed out that power of state health departments to enforce remedial measures has been established in Pennsylvania and Ohio. Evaporation of liquid wastes from coke plants by employing them for coke quenching appears to be most satisfactory method of disposal. **Stream Pollution in Ohio.** W. H. DITTOE. Ibid., 10–13. Progress in survey of stream pollution being conducted by State Dept. of Health is reviewed. In discussion it was stated that excess chlorine treatment for eliminating taste due to phenol was found ineffective in laboratory experiments at Cleveland. **Progress of Seal of Safety Campaign.** R. C. SWEENEY. Ibid., 13–17. Progress in program of examining and placarding semi-public water supplies in the State is outlined. At present time percentage figure of satisfactory semi-public supplies within Franklin County, where campaign was inaugurated, has reached 31. Of 685 public highway supplies examined throughout the State 61 are at present satisfactory and probably 80 per cent of remainder may be improved. **Use of Sodium Aluminate as a Coagulant**—Discussion. Ibid., 31–6. J. P. BROWNSTEAD reported that during 4-month period in 1924 when aluminate and alum were employed at Ashland, Ky., cost of coagulants averaged $9 per million gallons and reduction of bacteria was in excess of 90 per cent, compared with cost of $12 per million gallons, and bacterial reduction of 70 per cent with alum and lime during period in 1922 when somewhat similar river conditions prevailed. Results of 2-month experimental period during which aluminate was substituted for the lime ordinarly used with alum at Ironton, where coagulant is applied in primary and secondary basins in ratio of 2 to 1 respectively, are summarized by E. T. EDWARDS as follows: (1) A

trifle higher efficiency was obtained in primary basin, floc settling more rapidly and producing clearer effluent. This resulted in poorer filter efficiency and more algal trouble in the basins, but altering ratio of coagulant added in primary and secondary basins to 1:1 improved filter influent and efficiency. (2) When sodium aluminate below the normal lime application was employed, final effluent contained too great concentration of free carbon dioxide and had tendency to be corrosive. (3) Cost of treatment during period was higher than average of year, but cost of alum and lime would probably have also exceeded yearly average. Bottle experiments conducted by E. E. SMITH at Lima indicated that it would not be economical to replace any part of necessary application of alum with sodium aluminate. Use of latter with alum did not increase speed of reaction or produce larger floc particles. C. P. HOOVER, in discussing results of laboratory studies at Columbus, stated that addition of commercial sodium aluminate in softening by lime-soda process has same beneficial effect as alum. It is also an aid to softening due to its sodium carbonate and hydroxide content, whereas alum increases non-carbonate hardness and necessitates employment of additional soda ash. It is estimated that commercial sodium aluminate costs from 74 to 135 per cent more than equivalent mixture of alum, soda ash, and lime solutions. **Dry Feed of Coagulants**—Discussion. Ibid., 36–41. P. J. O'CONNOR reported that considerable trouble had been experienced at Warren with packing of chemicals in hopper of Gauntt type dry feed machine, particularly with lime. Type "P" machine of Pittsburgh Filter and Engineering Co., subsequently installed, had given very satisfactory results, except that at low rates of flow feed was 20–33 per cent high. W. I. VAN ARNUM stated that Gauntt dry feed machines had given entire satisfaction at Youngstown for application of hydrated lime, soda ash, and ground alum. Dry feed of alum and hydrated lime with machine of Pittsburgh Filter Manufacturing Co., had been found satisfactory at Ravenna, according to E. C. LINDSEY. Opinions expressed in discussion indicated that Gauntt type was not as accurate as Pittsburgh and other types when flow of water varied appreciably. **Water Purification at East Liverpool, O.** DANIEL H. RUPP. Ibid., 47–59. History of supply is briefly reviewed. Present system includes intake in Ohio River, grit chamber, 2 coagulation basins, 61-m.g. gravity concrete rapid sand filters, and pedestal type chlorinator. Tabulations of bacteriological data on operation of plant during 1923 are given. Coagulation removes 81–87 per cent of raw water bacteria; filtration 77–84 per cent of bacteria applied; and chlorination 94–97 per cent of bacteria surviving filtration. Final effluent after chlorination complies with proposed standards of U. S. P. H. S., but filter effluent before chlorination exceeded standard of 2 B. coli per 100 cc. during 5 months of year. Raw water is only slightly alkaline on average owing to acid sulfates discharged into river above intake. During one month incrustants averaged 188 p.p.m. Lime is regularly applied to correct corrosiveness of water, average pH being increased from 5.7 to 7.2. River water contains average of 4 p.p.m. of soluble iron and there is probably several times that amount of soluble alumina. This explains the comparatively small amount of coagulant required—0.7 to 1.5 g.p.g. Efficacy of purification of the supply is strikingly demonstrated in typhoid death rate, which was 75.8 per 100,000 during 4-year

period prior to adoption of filtration up to and including 1918, 38.1 during 4-year period following installation, up to and including 1922, when only indifferent part-time analytical supervision practiced, and 4.4 for past 2 years under full-time technical control. Considerable difficulty has been experienced with regard to tastes due to pollution of supply by phenol wastes. Study of the conditions indicates that tastes complained of are phenol tastes and not chlorophenol tastes as result of chlorination. Phenols in excess of 0.1 p.p.m. as determined with Folin-Denis reagent after distillation invariably results in complaints from consumers. Taste appears to be independent of residual chlorine content, which varies inversely with the organic content, being less when efficiency of coagulation decreases. Distinct removal of phenols and substances reacting with the Folin-Denis reagent is effected by purification process as a whole. Phenolic substances removed are not in suspension, and agency effecting removal is believed to be coagulation. When filter sand was cleaned in 1923 to remove incrustation, material removed was found to contain large proportion of phenolic substances, 100 gms. of incrusted sand yielding 15 mgm. of phenol on acidification with sulfuric acid and distillation. Test for tannins on this material, using ferric chloride, was negative. Chlorine treatment does not effect any removal of phenols, phenol content of filtered and of disinfected water being practically identical. Laboratory studies carried out to determine effect of various methods of treatment on phenol content are summarized as follows: (1) Treatment with sodium hypochlorite did not reduce phenol content of solution of chlorophenol containing equivalent of 1 p.p.m. of phenol. (2) Distilled water containing 1 p.p.m. of phenol showed same content of phenol after long standing. (3) Addition of 60 p.p.m. potassium permanganate to distilled water containing 1 p.p.m. of phenol did not alter phenol concentration, but 250 p.p.m. destroyed all phenol present. (4) Phenol content of distilled water was reduced from 1 to 0.5 p.p.m. by treatment with mangan-permutit. (5) Treatment with hydrochloric acid and potassium chlorate did not alter phenol content of distilled water. (6) Ohio River water containing 0.4 p.p.m. when treated with 3 g.p.g. of alum and sodium hydroxide showed after long standing reduction of phenol to 0.1 p.p.m. (7) Tannins distil over more slowly than phenols and are probably oxidized more readily in river water than phenol. (8) Original solution must contain as high as 20 p.p.m. of tannin in order for distillate to give color with Folin-Denis reagent equivalent to 1 p.p.m. of phenol. (9) Iron does not interfere with phenol determination unless present in concentration of 15 p.p.m., and such interference may be avoided by distillation of sample. (10) Phenol appears to undergo oxidation on long contact with river water; therefore proximity to source of pollution is factor in taste production. **Experiences in the Operation of the New Municipal Water Softening Plant at Newark, Ohio.** C. T. KAISER. Ibid., 60–4. New 6½ m.g. softening and purification plant treating Licking River water is described and data on operation given. Plant consists of mixing chambers, Dorr clarifier, settling basins, rapid sand filters and chlorinator. Split chemical treatment is employed, an average of 9 gr. of lime, 1.5 of soda ash and 1 of alum per gal. being applied to one-third of raw water flow, which after 20 minutes retention is mixed with remaining two-thirds. Hardness is reduced from average of 275 to average of 85 p.p.m.

When incrustant hardness is less than 40 p.p.m. use of soda ash is dispensed with. An average removal of 98.5 per cent of the suspended solids is effected by the Dorr clarifier. Carbonation is carried out by means of carbon dioxide applied through diffusers in outlet of settling basins. Use of scrubbed flue gas from hand-fired boilers for this purpose was found to give rise to chlorophenol tastes after chlorination and coke furnace has since been installed for generation of carbon dioxide, 100 lbs. of coke being required per million gals. The gas applied contains an average of 5 per cent carbon dioxide, while that emerging as bubbles from carbonation chamber contains 0.5 per cent. Process is controlled by hourly tests of phenolphthalein alkalinity, a concentration of approximately 1 p.p.m. of carbon dioxide being maintained in water applied to filters. If free carbon dioxide exceeds 2 p.p.m. an increase in total alkalinity of filtered water occurs, undoubtedly due to resolution of mat on filters. After 6 months operation no change in filter sand can be detected. In discussion, Oklahoma experiences were cited to show that phenols may also be present in flue gas of mechanically stoked boilers, but that introduction of chlorine in considerable amount into flue gas tends to eliminate taste producing constituents. Use of kerosene oil burners for generation of carbon dioxide was favorably commented upon. C. E. TROWBRIDGE stated that at South Pittsburgh, Pa., raw Monongahela River water is first treated at river pumping station with portion of the soda ash to neutralize acidity and thus protect pumps and piping. A portion of the raw water so treated is by-passed into remainder after latter has been softened and settled and before whole passes to filters, advantage thus being taken of large amount of carbon dioxide liberated by soda ash treatment to effect recarbonation. This practice places no undue bacterial burden on filtration process as river water is practically sterile due to the acidity. **The New Water Purification Plant at Toronto, Ohio, Employing Double Coagulation of Ohio River Water.** DANIEL H. RUPP. Ibid., 65–7. History of water supply of Toronto is outlined and new plant consisting of mixing chamber, coagulation basins, gravity rapid sand filters, and chlorinator described. Double coagulation is employed at all times, it having been found that best results with least application of chemicals can be obtained thereby. Amount of alum used has averaged 3 g.p.g., in approximate ratio of 2:1 to first and second basin respectively, and lime employed has averaged 2 g.p.g. With exception of first month of operation filtered water before chlorination has met requirement of original standard of U. S. P. H. S. (2 B. coli per 100 cc.) and after disinfection with approximately 0.2 p.p.m. of chlorine, giving residual of 0.1 to 0.15 p.p.m. in tap water, final effluent has easily conformed to revised standard (1 B. coli per 100 cc.). **The Cincinnati Water Works System.** CLARENCE BAHLMAN. Ibid., 68–74. Water supply history is outlined and existing system described in detail. Present purification plant consists of settling reservoirs, coagulation basins, and 28 4-m.g.d. rapid sand filters operated of rate of 123 m.g. per acre per day. Power for operation of plant is derived from hydro-electric units installed on pipelines conveying water from settling basins to purification plant, available head being approximately 27 feet. Settling reservoirs remove an average of 70 per cent of bacteria and turbidity present in raw Ohio River water and coagulation basins about 20 per cent. Average B. coli content of river water during past 17 years

has ranged from 1700 to 3400 per 100 cc. Coagulation is effected with lime and iron sulfate. Quicklime is purchased in lump form and is slaked with filtered water at temperature of 140°F., when boiler plant is in operation. During period May–September inclusive, when cold water is employed, extraction is not so complete, but loss is immaterial in comparison with cost of operating boiler plant. Considerable difficulty has been experienced due to incrustation of lime solution pipeline, which is 900 ft. in length. Cost of operation during 1923 was equivalent to $6.76 per m.g. delivered into service, of which $2.44 was expended on chemicals. There are now over 800 miles of water mains and supply is practically 100 per cent metered. Boiler feed water employed consists of mixture of 85 per cent condensate, freed from oil by treatment with alum and caustic soda followed by sand filtration, and 15 per cent permutit-softened water. **An Investigation of Variations in Bacterial Quality of Cincinnati Water Supply.** CLARENCE BAHLMAN. Ibid., 75–84. Considerable data derived from bacteriological study of water supplied to consumers in Cincinnati with particular reference to chlorine applied and to multiplication of bacteria during distribution, is given. Chlorine dose at present employed varies from 0.18 to 0.27 p.p.m., former being applied during winter months and latter during periods of maximum water temperature. During former season residual chlorine content of tap water varies from 0.01 to 0.04 p.p.m. but during summer and autumn free chlorine in water delivered is practically nil and during this period highest B. coli content is recorded. An increase in colon and other bacteria, particularly during summer months, was found to occur even in the suburban distribution system on which there is no open reservoir. The higher colon content recorded in water from downtown taps than from purification plant effluent was shown to be due to comparatively high B. coli content of water in the pure water reservoir which is exposed to falling leaves and atmospheric dust. Since contamination with human wastes is most improbable, little sanitary significance is attached to increased number of bacteria in reservoir water. The ultimate tap water conforms to proposed standard of U. S. P. H. S. **Spore-Bearing Gas-Formers in the Ohio River at Cincinnati.** HENRY SOHN. Ibid., 85–9. Of 99 samples of Ohio River water examined for spore-bearing gas-formers during period March–October 1924, 21 were found to contain such organisms. Of these unpurified cultures 18 were capable of growing aërobically and 16 grew anaërobically. Only 6 of the 21 positive mixed cultures survived plating and purifying processes and proved capable of fermenting lactose. All 6 were spore-bearers and 4 of them grew aërobically. Remaining 15 positive cultures were apparently due to symbiotic growth of spore-bearing types. Rate of gas formation by spore-bearing types encountered was too slow to cause serious interference with gas production by colon group organisms. During same period 85 per cent of routine presumptive positive tests on Ohio River water confirmed when subjected to usual confirmatory tests for B. coli.—*R. E. Thompson.*

Decision of Court in Patent Case. A decision in the suit of the Electro Bleaching Gas Company and Wallace & Tiernan Company, Inc., against Paradon Engineering Company, in the United States District Court of New York, has been rendered in favor of the plaintiffs. The court held that the

Paradon Chlorinator was an infringement of the Ornstein patent on the solution feed process for the chlorination of water and sewage.—*A. W. Blohm.*

Powdered Coal at Water Plant Proves Saving. Newspaper Item. A coal crusher placed directly in front of boiler reduces coal to powder as it is needed to feed fires. The cost of installing the machine at Des Moines municipal water plant was about $2,500 and the saving from its use is estimated at approximately $7,500 per year. The coal enters the furnace in a spray much as though it were oil being sprayed into the firebox. As it travels through the furnace, the coal is gasified and more air is admittted to secure complete combustion. —*A. W. Blohm.*

Water Supply and Purification. Amer. Jour. Pub. Health, 15: 4, 314, April, 1925. Progress report of Committee on Water Supply and Purification calls attention to the following: injunction granted by Supreme Court of Pennsylvania, restricting discharge of acid mine drainage into water supply; application of iodine salt to Rochester, N. Y. Water Supply; purification programs of different cities; studies of filter media for rapid sand plants; water softening; improved physical qualities and aëration.—*A. W. Blohm.*

Boiler Corrosion and the Treatment of Boiler Feed Water. A. WINSTANLEY. Water & Water Eng., 26: 65, February 20, 1924. *Pitting:* (a) Action of salts. Sulphur, liberated by decomposition of calcium sulphide formed by heating calcium sulphate with carbon, produces local corrosion. The carbon may be present in the steel or may be produced from a drop of oil deposit. (*b*) Action of gases. Two theories concerning action of oxygen. (*c*) Action of oil. Animal or vegetable oils are readily split up by heating into glycerine and free acid, latter of which attacks boiler plates producing black, greasy compound. Mineral oils are not usually decomposed to acids, but may cause injury by settling on plates and, by causing local higher temperature, promoting galvanic action. (*d*) Galvanic Action. The two important points to be considered are: (1) Possible potential differences; (2) Factors influencing conductivity of the water. To repress galvanic action, apart from introduction of zinc slabs, water should be de-aërated and treated to reduce salt concentration; purer steel should be used; thick and hard scale should be avoided by water treatment and by frequent cleaning; (*e*) Lime Soda Process and Pitting. In 45 boilers which showed pitting, feed water was treated by this process. In 6 cases the feed water contained more than 10 grains per gallon of sodium salts naturally. In all cases hardness less than 6 degrees. Experiments were made to ascertain effects of concentrated sodium sulphate solutions on new boiler steel by suspending test pieces below water level in Lancashire boilers, using water previously treated by lime soda process. Of 10 samples, kept in boilers from 6 to 10 months, pittings were visible to naked eye on 4, under hand lens on 4 more, and under microscope on remaining two. Tests did not indicate much embrittlement, or reduction in strength. *Grooving.* Is usually most pronounced on upper side of furnace tube at furnace end. Appears to be essentially mechanical process, although possibly influenced by composition of water. More cases have been noticed where distance between rivets attach-

ing furnace tubes to end plates and inner rivets of gusset stays is relatively small. It also appears to be more prevalent in boilers having either thick or hard scale. *Treatment of Boiler Feed Water.* Point is emphasised that insufficient attention is paid to matter remaining in solution in boilers. Water with low degree of hardness appears to be usual requirement, and lime soda process the usual treatment. Analyses given show that after normal periods of running, 5 to 7 weeks, total matter in solution varied from 1452 to 2981 grains per gallon, mainly sodium sulphate and sodium chloride. Not only is additional heat required to evaporate such concentrated solutions, but temperature of water exceeds that of steam with result that foaming occurs and particles of salt are often swept into steam pipes and engines. It is recommended that concentration of boiler water be determined at intervals and never allowed to exceed 0.4 pound per gallon. For matter precipitated in boiler, maximum of ¼ pound per square foot of interior surface is suggested for incrustant salts and double this for sludge, or non-scale-forming material.—*Geo. C. Bunker.*

Tansa Completion Works. Water & Water Eng., 26: 97, March 20, 1924. Description of fabrication, transportation, and laying of steel pipe lines 55 miles long, from Tansa Lake to city of Bombay, India. Two parallel pipelines, each 72 inches in diameter, are being laid from Tansa to Powai, and three lines from that point on, two of them, each 75 inches in diameter, to Bombay direct, and the third, 60 inches in diameter, to Ghatkoper, there to connect with two existing 48 inch Tansa mains. These lines will convey at first 90 million gallons per day, which can be increased to 160 million gallons without further alteration. The steel plates, ⅜ inch thick, 7 feet 4½ inches wide, and from about 15 to 20 feet long, according to the 3 sizes of pipes required, were drilled for rivets, planed to a bevel suitable for caulking, and scarfed at corners in England. They were then shipped to India for fabrication. The specials were fabricated in England. With a view to reducing field riveting to a minimum, very careful and exhaustive tests of pipe were made in England. These demonstrated that hydraulic riveting in the shop is infinitely preferable to pneumatic riveting in the field. Twenty-four hydraulic riveting machines, each weighing 8 tons and capable of exerting a squeeze of 60 tons on each rivet, are used in the shop in India, reducing the field riveting to one-twelfth of the whole. The pipes leave the shops in 57-foot lengths, fully riveted and caulked. The interior surface is covered with bituminous solution by pneumatic sprayers. Steam driven air compressors are used for riveting and caulking field joints. Painting of outside of pipe lines will not be done for several months so as to allow weather to remove mill scale before hand painting. At intervals of about 4 miles is provided an elaborate system of valves and cross-connection which will rest on solid blocks of concrete to prevent any movement due to rise in pressure when closing valves. Air valves are provided at high spots and scour valves at low spots. Expansion joint is provided every 1000 feet in order to relieve circumferential field joints from temperature stresses. It has been found by actual experience that each 1000 feet of pipe, when empty, has moved in and out of the expansion joint as much as 6½ inches on a warm day, and it is calculated that movement may be as much as 8½ inches in very

hot weather. Curves are turned by means of special taper pieces hydraulically riveted to ends of 57-foot lengths in the shop. It is expected that work will be finished before end of 1925. Illus.—*Geo. C. Bunker.*

The Influence of Hydrogen Ion Concentration on the Dose of Alum and the Mechanism of the Action of Alum in the Clarification of Natural Waters. NANI LAL BANERJI. Water & Water Eng., **26**: 104, March 20, 1924. (Abstract from the Indian Journal of Medical Research, January, 1924.) River Hooghly is the source of water supply for Calcutta and other suburban municipalities. Every year during monsoon, middle to end of June, it assumes reddish appearance from iron oxide silt from red soil, brought down by one or other of tributaries. The main bulk of silt consists of extremely fine particles which interfere with sedimentation and require usually high dose of alum for clarification. Last year fineness of particles was such that clarification was not complete and Calcutta filtered water, instead of being clear and transparent as usual, was decidedly opalescent. This caused a certain amount of agitation among public as to purity of water supply. Later on, lime was used with alumino-ferric to hasten sedimentation. Author's investigations led him to conclude that addition of lime was not justified either on theoretical grounds, or by results in practice. Four conclusions are drawn by the author from his experiments namely: (1) Other factors remaining constant, viz., suspended matter, size of particles, and concentration of electrolytes, optimum dose of alum increases as pH increases and decreases as pH decreases. (2) Total hardness plays important rôle in regulating dose. (3) Mechanism of action of aluminum sulphate is divided into two portions due respectively to (1) unhydrolysed aluminium sulphate, and (2) hydrolysed aluminium sulphate, which again is made up of two components: (*a*) sulphuric acid, (*b*) aluminium hydroxide. Positive aluminium ion from unhydrolysed portion is most potent factor in clarification. Next comes hydrogen ion from sulphuric acid. Last and least is $Al(OH)_3$ solution. (4) Dose of alum can be decreased by preliminary addition of cheap acid, such as sulphuric. During monsoon, as much as 1 ton of alumino-ferric is used daily by Calcutta. In view of facts revealed by this investigation, consumption of alum can be lessened by using acidulated water instead of ordinary water in dissolving tank. Addition of acid is limited by pH of water. If original pH be not high, we cannot acidify water too much, because it may affect taste and injure machinery. Dose of alum and acid can be so regulated that resultant pH shall not greatly differ from absolute neutral point, 7.0, in which case taste and machinery will remain unaffected.—*Geo. C. Bunker.*

Water Softening by Means of Doucil. T. P. HILDITCH and H. J. WHEATON. Water & Water Eng. **26**: 109, March 20, 1924. Description of comparatively new base-exchange material manufactured by J. Crosfield & Sons, of Warrington, England, under name of "doucil." It is a complex silicate, containing replaceable combined soda, in form of dried gel and is marketed on a 50 per cent moisture basis, which means that 1 ton will soften to "zero hardness" about 22,000 gallons of water. For treating this volume of water doucil bed 6 feet deep in cylindrical shell about 3 feet 6 inches in diameter by 8 feet high

would be suitable; with brine tank of about 360 gals. A 6-foot bed will soften 15 to 20 per cent more water than two 3-foot beds of same area. The preferred size of grain is now from $\frac{1}{8}$ to $\frac{1}{20}$ inch; resistance offered by 6-foot bed of this size is only about 1 pound per square inch at normal rates of flow. (Cf. this JOURNAL **12**: 2, 255–6.)—*Geo. C. Bunker.*

A Unique Equilibrium Ball Valve. Water & Water Eng., **26**: 111, March 20, 1924. Note concerning two very large 25-inch diameter bronze valves constructed for Talybont waterworks scheme of Newport Corporation by Glenfield & Kennedy of Kilmarnock. Weight of each valve is approximately 9912 pounds; working pressure is 214 feet but shop tests of 400 feet have been made. Illus.—*Geo C. Bunker.*

Water Purification for Industrial Purposes. J. P. O'CALLAGHAN. Water & Water Eng., **26**: 112, March 20, 1924. Description is first given of 4 million Imp. gallons per day rapid sand filter plant at Becton works of Gas Light & Coke Co. Raw water is taken from Thames River. Advantages and economies of softening water for boilers by lime-soda and permutit, or zeolite, processes are discussed. In many respects zeolite softening offers great attractions; but this treatment alone is not usually economical where hardness exceeds 40 grains per gallon: in such cases a combined lime-soda and zeolite plant can be effectively employed. By a modification of permutit process minute quantities of iron and manganese and all organic matter may be removed. By treating sodium permutit with a manganese salt, manganese permutit is produced, by which all iron and manganese salts are oxidized and precipitated, and at same time, all organic matter and bacteria are also oxidized. Manganese permutit must be periodically regenerated by addition of potassium permanganate. Great success of French silk industry is mostly due to purity of water used. The largest of the French silk houses has installed permutit process to remove about 5 degrees of hardness from water supply.—*Geo. C. Bunker.*

Relation of Boiler House Equipment to Plant Economy. THEODORE MAYNZ. Chem. and Met. Eng., **32**: 17, 851–2, November, 1925. Boiler plants should have earning capacity above interest and investment charges. If power cannot be produced cheaper than it can be purchased, it should be purchased. Boiler plants for 24-hour production should have equipment that is reliable and of high economy. Such plants should have at least three boilers, any two of which will carry the load without excessive ratings. Feed pumps should be in duplicate, draft apparatus so arranged that any unit can be taken out of service for repairs, and ash and coal handling apparatus so arranged that their failure will not put plant out of operation. Boilers should be equipped with stop and non-return valves, soot blowers, flow meters, CO_2 recorders, draft gages, flue temperature recorders, and automatic stokers or pulverized coal equipment. Hand fires have no place in 24-hour plant, even with cheap coal. Equipment must be suitable for conditions under which it is to operate, and must be properly installed. Boiler plants operating 10 or 12 hours a day with low load factor cannot afford any thing but simplest and most inexpensive

apparatus that will perform the work. Hand fires, hand lance flue cleaning, cheap water meter, and simple coal handling are all that will pay dividends unless fuel is extremely high. Operation of average industrial boiler plant is inefficient.—*John R Baylis.*

Stream Pollution—a Symposium. Proc. Am. Soc. Civ. Eng., 51: 9, 1809–55, November 1925. **A Review of the Work of the United States Public Health Service in Investigations of Stream Pollution.** W. H. Frost. In March, 1901, Congress provided for erection of laboratory by U. S. Public Health Service for investigation of contagious and infectious diseases and matters pertaining to public health, and in same year Division of Scientific Research was organized. In 1910, first systematic investigation of status and effect of sewage pollution in any large area was begun on cities in Great Lakes region. Duties of Public Health Service were extended in 1912 to include diseases of man and conditions influencing propagation and spread thereof, including sanitation, sewage, and pollution of navigable streams and lakes of United States. Field laboratories were established for first time in 1913. Comprised amongst work undertaken have been studies of bio-chemistry of sewage and industrial wastes, studies to devise better methods for treatment of various important industrial wastes, study of pollution and natural purification of Potomac and Ohio Rivers, survey of municipal sewage disposal plants in various parts of the U. S., and collective study of municipal water purification plants as operated on Ohio River and elsewhere. **The Rate of Deoxygenation of Polluted Waters.** Emery J. Theriault. The Phelps formula holds with reasonable accuracy when applied to samples recently polluted with organic matter. For periods of incubation of less than 10 days it is possible to refer results obtained under standardized laboratory conditions to actual times of flow and temperatures of stream. Under aërobic conditions, stabilization of organic matter apparently proceeds in two distinct stages. Rate at which polluted water is deoxygenated depends largely on condition of sample with respect to its state of oxidation. Complete solution of problem probably depends on development of methods whereby state of oxidation of a sample may be determined more rapidly. **The Rate of Atmospheric Reaëration of Sewage Polluted Streams.** H. W. Streeter. The reaëration of flowing streams proceeds substantially in accordance with physical laws which have already been described. Rate at any time is controlled mainly by temperature, turbulence and oxygen saturation deficit of stream. An empirical method of measuring rates of reaëration is described. By proper combination of predetermined rates of reoxygenation and of reaction a reasonably accurate calculation may be made of resultant progressive changes in dissolved oxygen content of a stream under any given or assumed condition of flow, temperature, and initial degree of pollution. **Quantitative Studies of Bacterial Pollution and Natural Purification in the Ohio and the Illinois Rivers.** J. K. Hoskins. Observations of pollution of these rivers indicate that number of bacteria contributed per capita by sewered populations of various cities are reasonably constant. Method is suggested for estimating maximum concentration of B. coli in streams of known volume of flow that may be expected from known sewered populations.—*John R. Baylis.*

Natural Water Corrosion and H-Ion Concentration. JOHN R. BAYLIS. Chem. and Met. Eng., **32**: 17, 874–5, November, 1925. Experiments do not confirm the work of several authors that over 3.0 parts per million of soluble iron will exist in water free from dissolved oxygen when pH is between 8 and 9. Solubility equilibrium of ferrous carbonate largely determines whether or not water will stain after passing through iron pipes. Alkalinity and pH affect this equilibrium. Solution inside an active tubercle and pit maintains pH close to 6.0, regardless of that of outside water. Tubercles overlying pits tend to form impervious layer of crystalline iron oxide near surface of tubercle. This eventually stops corrosion unless impervious layer becomes broken. Alkaline waters heal such breaks more readily than neutral or slightly acid waters.—*Frank Hannan.*

Utilizable Capacity of Steel Members of Structures. HENRY S. PRICHARD. Proc. Am. Soc. Civ. Eng. **51**: 9, 1735–92, November, 1925. Fundamental factors on which utilizable capacity of steel members of structures depends and methods of determining such capacities are given. Utilizable capacity of any steel member is measured by greatest load which can be applied during life time of structure without causing failure, ruin, or objectionable deformation.—*John R. Baylis.*

Queen Mary's Reservoir. Anon. Public Works, **56**: 320, 1925. Reservoir covers 723 acres, has capacity of 6,000 million gallons, average depth of 38 feet, and artificial embankment lined with concrete slabs.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Hetch Hetchy Bay Crossing Division. Anon. Public Works, **56**: 371–74, 1925. Construction features of twenty mile pipe line for San Francisco Bay Crossing Division of Hetch Hetchy water supply project are given. Line consists of 60-inch riveted steel pipe laid partly on a trestle and on a 36 span steel bridge, and of 42 inch submarine type flexible-joint cast iron pipe under water ways.—*C. C. Ruchhoft.*

Denver's Concrete Sand Trap. IVAN E. HOUK. Public Works, **56**: 378, 1925. Trap is concrete box, 2.5 feet deep and 18 feet wide, set transversely in bottom of Denver Water Company's High Line Canal and located about a mile below canal intake on South Platte river and about a quarter mile above the 300 million gallon Platte Canyon reservoir. Trap is provided with gates on one side so that sand which settles in it may be sluiced back into river.—*C. C. Ruchhoft.*

Hydrogen Ion Concentration and pH. LINN H. ENSLOW. Public Works, **56**: 361–66, 1925. General description of significance of pH and its rôle in practical filter plant operation.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Water Works Plans for New Jersey Municipalities. Anon. Public Works, **56**: 374–75, 1925. Changes in rules and regulations of State Department of Health governing preparation and submission of plans for water supply and purification works.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Customer Ownership Plan for Water Companies. PHILIP B. NILES. Engr. & Contr., **64**: 106–9, 1925. Advertising and sales methods used by Terre Haute Water Works Corporation to sell its stock to its consumers are described.—*C. C. Ruchhoft.*

Simple Solution of Hydraulic Problems. ROBERT W. ANGUS. Engr. & Contr., **64**: 81–5, 1925. Practical methods are given for solving loss of head in pipe and other water works problems.—*C. C. Ruchhoft.*

Town Solves Fire Flow Problem with Standpipe. HARRY F. HUY. Engr. & Contr. **64**: 94–6, 1925. Village of La Salle, New York, obtains its supply from adjoining city of Niagara Falls. During times of fire, residual pressure in mains of village sometimes dropped to 10 pounds and village received low insurance rating. To remedy this standpipe 35 feet in diameter and 100 feet high was constructed in central situation.—*C. C. Ruchhoft.*

Denver's New Water Supply Conduit. Anon. Public Works, **56**: 271–5, 1925. Construction of 66-inch pre-cast reinforced concrete pipeline six miles long, connecting clear water reservoir at Marston Lake filter plant with city, is described. At Bear Creek crossing, $\frac{7}{16}$-inch steel pipes were laid on two rows of timber piles and encased in concrete.—*C. C. Ruchhoft.*

Reservoir and Pipeline Tunnel for Calumet City, Illinois. ERNEST A. CLARK. Engr. & Contr., **63**: 1041–6, 1925. Construction of circular reinforced concrete reservoir 180 feet in diameter and 13 feet high with capacity of 2,000,000 gallons and of 7 by 7 foot water pipe siphon tunnel under Calumet River are described.—*C. C. Ruchhoft.*

Constructing Reinforced Concrete Reservoir. Anon. Public Works, **56**: 213–4, 1925. Construction features for Eastern Hills reservoir at Cincinnati are described. Reservoir is 400 feet square by 30 feet deep with a capacity of 35,000,000 gallons.—*C. C. Ruchhoft.*

The Madrid Water Supply. Anon. Engr. & Contr. **64**: 103–5, 1925. The history, present installation, and proposed extensions to conduits of Madrid supply are described.—*C. C. Ruchhoft.*

Care of Concrete Reservoirs. R. E. MCDONNELL. Munic. & County Eng., **68**: 233–35, 1925. It is almost impossible to build large concrete reservoir and not have leakage. Best ways to avoid leakage are:—"(1) A careful study and test of the soil and material used in construction. (2) Design and plans utilizing the best recognized engineering skill with ample factor of safety. (3) Inspection of the most rigid character."—*C. C. Ruchhoft.*

Methods and Policies of Preventing Stream Pollution. H. V. PEDERSON. Munic. & County Eng., **68**: 133–35, 1925. Stream pollution situation in Iowa is discussed and conservative policy in prevention of stream pollution is advised.—*C. C. Ruchhoft.*

Review of Water Purification Fundamentals. J. B. MARCELLUS. Munic. & County Eng., **68**: 243–45, 1925. General article in which examination of water, bacteria, water treatments, and filtration are discussed in simple language.—*C. C. Ruchhoft.*

A Modern Water Softening and Filtration Plant. Anon. Fire and Water Eng., **78**: 399 (1925); Pub. Health Eng. Abst., September 5, 1925, Water Supplies p. 50. The Miami, Florida, supply is derived from 9 wells. It is treated with lime, alum, carbonated and filtered.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Northern New Jersey's Proposed New Water Supply. MORRIS R. SHERRERD. Fire and Water Eng., **78**: 403 and 430 (1925); Pub. Health Eng. Abst., September 5, 1925, Water Supplies, p. 50. Plan of development in five steps over a period of 55 yrs. Chimney Rock reservoir, the Raritan, the tributaries of the upper Delaware river, and finally part of the flow of the Delaware itself are considered. Entire yield estimated to be 750 m.g.d. with cost about $86,000,000.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Measures Being Taken to Improve the Water Supply Systems in Porto Rico. OCTAVIO MARCANO. Porto Rico Health Bul., 1, 23–29 (1925); Pub. Health Eng. Abst., September 19, 1925, Water Supplies, p. 54. Supplies of 46 communities serve 25 per cent of the population. Most supplies are derived from polluted surface sources which are turbid at times. San Juan water works of 1899 is now inadequate and is being supplemented by an 8 m.g.d. rapid sand filter plant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Medium for the Differentiation of B. coli in Water Analysis. J. L. PAWAN. Annals of Tropical Med. and Parasitology, **19**: 319–326 (1925); Pub. Health Eng. Abst., September 26, 1925, Water Supplies, p. 56. Brief summary of British and American methods is given. Water borne disease in tropics is rare though the population uses a polluted water supply of high coli index figured on the British standard (Lactose plus, Indol plus). This situation may be due to accidental absence of pathogens, the sterilizing effect of the tropical sun or to an improper coli index due to failure to differentiate between fecal and non-fecal forms. After applying various tests, the medium of Koser (*J. Bact.* 9, 59, 1924) is credited with being best. The author considers it much superior to the methyl red and Voges-Proskauer tests.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Treatment of Alkali and Other Waters for Domestic Use. G. A. CUMMINGS. Colorado Agr. Expt. Sta. Rept., p. 40 (1924); Expt. Sta. Rec., 53,185 (1925); Pub. Health Eng. Abst., September 26, 1925, Water Supplies, p. 57. Distillation is the only suitable method.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Filtration of Swimming Baths. ANON. J. Roy San. Inst., **46**: 47–52, 1925. Discussion of costs involved. Chloros is recommended as disinfectant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The "Guta" Automatic Chemical Control Apparatus. E. DEPLANTADE. La Technique Sanitaire, **20**: 106–110, 1925. Control of chemical feed by varying head on orifice connected by tube to solution reservoir. Control of height is accomplished by float connected to orifice tube by cord carried over pulley or by counterpoised vessel containing variable quantity of water. Rate of flow of water supply determines height of liquid in float chamber or counterpoised vessel.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Determination of Minute Amounts of Phenols in Polluted Natural Waters. LOREN R. VORCE. Ind. Eng. Chem., **11**: 751, 1925. Two or three l. of water are freed as well as possible from Ca, Mg, etc., by treatment with NaOH and filtration. H_2O_2 free from compounds with benzene nucleus is added and allowed to stand over night. Resulting solution is concentrated to 200 cc. in strong alkaline condition, made acid by addition of citric acid crystals, and distilled. In distillate, phenol is determined colorimetrically by use of Folin and Denis reagent.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Economical Use of Alum in Mechanical Filters. A. D. STEWART and V. GOVINDA RAJU. Water and Water Eng., **27**: 273–274, 1925. Rapid sand filters operating on clear waters which have had some storage reach maximum efficiency after being fed with coagulated water for one hour; use of alum thereafter can be dispensed with without impairing efficiency. This allows reduction of chemical cost.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Surface Tension as a Factor in the Priming of Steam Boilers. E. B. MILLARD and T. E. MATTSON. Ind. Eng. Chem., **17**: 685–686, 1925. No connection exists between surface tension and priming of boiler waters.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Primary Filtration for Municipal Water Supply. J. A. BERNARD. La Technique Sanitaire. **20**: 25–26, 1925. Details of St. Denis plant. Water is taken from St. Denis river. Settling basin has four compartments, each provided with inlet, discharge channel, 2 copper screens, drain, and opening and closing mechanism. Water enters base of filters and passes upward to service tank and thence to mains.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Algal Growths in Tank Waters. V. GOVINDA RAJU. Water and Water Eng., **27**: 57, 1925. Algae seem to prefer temperature of about 75°F. and die off as reservoirs get low and the water goes above that temperature. They then decompose and give off bad odors. Copper sulphate and lime have not been very effective under Indian conditions. H_2SO_4 in amount necessary to neutralize bicarbonates has been very successful. It is not necessary to add the dose all at once. Most important algae have been (1) Oscillaria; (2) Anabaena, (3) Cylindrospermum, (4) Navicula. A euglena forms thick red coating at times on water. Spirogyra is most important layer form of alga.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Silt Equilibrium. HERBERT CHATLEY. Water and Water Eng., **27**: 95, 1925. Airy says that weights of individual particles vary as 6th power of

velocity of stream carrying them. C. finds that this does not apply to non-turbulent flow. In this case weight varies as the 1.5 power of velocity. Particles settle with long diameter across bottom of stream at right angles to direction of flow.—*Jack J. Hinman, Jr.* (*Courtesy Chem Abst.*)

The Thiem System of Constructing Tubular Wells. Ed. Imbeaux. La Technique Sanitaire. June, 1925. Consists of number of small but deep borings over catchment area. Each well has head works, main tube for catchment, copper suction tube, observation tube discharging at surface level, and collecting conduit. Excavation is limited to shaft boring and ordinary conduit trenches. Found to yield better than few large wells with collecting tunnels. Whole of Leipzig supply collected by Thiem system.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Influence of Forest Land on Runoff. L. W. Collet. La Technique Sanitaire, **20**: 167–168, 1925. Comparison of thickly wooded and slightly wooded areas showed runoff from former considerably greater. In dry periods, torrent from wooded land flowed, while that from open land dried up. Grass land is not very absorbent. Upper 18 inches of forest land is permeable. Idea that leaves and vegetable debris retain much water is erroneous.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Condensation of Water in the Ground. J. Versluys. Water en Gas, July 3, 1925, p. 144. Condensation of gases by absorption takes place on surface of solid bodies and is most intense in capillary spaces. Water may condense from soil air even though latter be not saturated. Between adjacent grains drop with concave surface forms and increases in size until equilibrium has been attained. These drops probably do not fuse and flow into the ground water, but probably are available to rootlets of plants, absorption by which of water may disturb the equilibrium and induce further condensation.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water Supply of the City of Aberdeen. George Mitchell. Water and Water Eng. **27**: 56, 1925. Old works 20 miles west of city took water from river Dee; consisted of 12 mg. storage reservoir, ½ acre of slow sand filter, and 18.5 miles of brick aqueduct. Capacity 8.5 m.g.d. Enteric epidemic in 1912 was at first ascribed to the water, though now believed to have been due to milk. New scheme authorized for water supply in 1916 is based on 40 Imp. gals. per day per person for population of 240,000. It consists of screen and intake chamber leading to 60 inch conduit and new 24 mg. concrete storage reservoir. There are 3 new filters of a total area of 1.4 acres arranged to be cleaned by squeegeeing instead of by scraping. Water of Dee is very clear.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Softening: the Essential Principles Involved. Anon. Water and Water Eng., **27**: 361–362, 1925. Colliery waters are best softened by lime and soda hot process. Zeolites are attacked by acids in these waters and interfered with by the iron and oil.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Short History of the Keighley, England, Water Works. M. RATCLIFFE BARNETT. Water and Water Eng., **27**: 345, 1925. Original supply from wells or springs established in 1816 was superseded in 1891 by slow sand filtration system. Water is treated with Na_2CO_3 before filtration to reduce plumbosolvency and is passed after filtration through beds of polarite. Illustrations of plant.—*Jack J. Hinman, Jr.* (*Courtesy Chem Abst.*)

Water Supply in Holland. F. A. LIEFRINCK. Water and Water Eng., 27, 356–361, 1925. Oldest public system is that of Amsterdam constructed in 1853. 108 undertakings supply 325 communities; 4.6 million out of 7 million inhabitants are supplied from public supplies. Peculiarities of ground water in sand dunes close to the sea is discussed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report of Bureau of Sanitary Engineering, Maryland State Department of Health, 1924. ABEL WOLMAN. 15 pp. Admirable presentation of work of Bureau during 1924, which included investigations in connection with new water supply and sewage disposal undertakings, routine control of existing system, stream pollution studies, oyster pollution investigations, flood control and sanitary surveys. Considerable progress was made in regard to water supply sanitation, the Legislature having granted enabling Acts for bond issues totalling $19,000,000 for water and sewage improvements. Study of effect of water purified by modern methods upon goldfish showed that fish life is not seriously affected by chlorine in doses as high as 3 p.p.m., and that acids, copper sulfate and alum in usual amounts do not detrimentally affect gold fish, minnows and trout. Goldfish mortality in Baltimore was found due to excessive amount of dissolved oxygen in the water. Rapid change in dissolved oxygen content causes great discomfort to fish, high concentrations causing death in very short time. Mortality of goldfish is low at temperatures above 50°, while below this point fish become sluggish, being practically dormant at 40°. Study of treatment of a highly colored deep well water of high silica content showed optimum pH for coagulation of this water to be approximately 8.6, addition of lime prior to coagulation being necessary. Survey of treated water reservoirs in Baltimore disclosed fact that some are exposed to surface pollution of possible human origin, and plans have been made for more careful control and for installation of chlorination apparatus for secondary treatment. Examination of water from 62 individual wells in connection with extension of supply of Salisbury showed water from wells in excess of 100 feet deep to be high in iron and practically devoid of oxygen, that from wells 50–100 feet deep to be low in iron and hardness, and that from under 50 feet to be low in alkalinity and iron but high in chlorine and free carbon dioxide. Water from all wells was corrosive. Depth of 100–150 feet was recommended. Investigations were made during year of stream pollution arising from discharge of wastes from various industries,—tanneries, creameries, canneries, oil refineries, etc. Investigation of action of chenopodium oil upon fish life showed that detrimetal effect was due to toxic nature of the oil and not to loss of dissolved oxygen or to acidity. Concentrations of less than 50 p.p.m. are not fatal to fish unless period of exposure is longer than 3 hours. Data on

pollution of Antietam Creek between Bridgeport and Funkstown and conclusions derived from study of same are given. Typhoid death rate during year was 6.4 and 10.3, inclusive and exclusive of Baltimore respectively.—*R. E. Thompson.*

Purifying Industrial Water. D. H. KILLEFFER. Ind. Eng. Chem., **15**: 915–7, 1923. From chem. Abst. **17**: 3393, October 20, 1923. General discussion of character of water from different sources, softening by precipitation and zeolite methods, and uses of treated water in various industries.—*R. E. Thompson.*

Sterilization of Drinking Water With Chlorine. J. VERSLUYS. Arch. Suikerind, **31**: 687–96, 1923. From Chem. Abst., **17**: 3393, October 20, 1923. Chlorine in doses of 0.75–1, and at times as high as 1.7, grams per cubic meter are employed in purification of river water at Soerabaia, Java, excess being removed with sodium sulfite.—*R. E. Thompson.*

Chicago Menaced by Goiter. Anon. Chicago Dept. of Health, Weekly Bull., **17**: No. 34, (new series) 137–44, August 25, 1923. From Chem. Abst. **17**: 3393, October 20, 1923. Lake Michigan water contains 0.281–0.681 parts per billion of iodine and it would cost $57,120 per year for sufficient sodium iodide to increase iodine content to $\frac{1}{7\frac{1}{2}}$ grains per gallon. Chocolate tablets containing organic iodide recommended.—*R. E. Thompson.*

Use of Aluminium to Prevent Steel Corrosion. A. V. FARR. Chem. Met. Eng., **29**: 1188–9, 1923. From Chem. Abst., **18**: 965, April 10, 1924. Process known as calorizing, consisting of alloying surface of steel with aluminium, protects steel against corrosion.—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Different Kinds of Glassware When Sterilized With Buffered and Nonbuffered Solutions. F. W. FABRIAN. Mich. Sta. Rept., 1921, 173–8; Expt. Sta. Rec., **48**: 204. From Chem. Abst., **17**: 3350, October 20, 1923. Data reported from study by R. C. STULL. For nonbuffered solution triple distilled water was used and for buffered solution standard nutrient broth, both being adjusted to pH 7. Determination of pH was made colorimetrically with Clark and Lubs indicators in Cooledge comparator. Tabulated results showed that glassware taken from stock and filled with nonbuffered solution yielded enough alkali during autoclaving to change reaction from pH 7 to 9.8. Amount of alkali yielded by same glass was not sufficient, however, to change reaction of buffered solution during autoclaving. Soft glass yielded more alkali on autoclaving than did hard glass. Treatment of glass with cleaning solution did not prevent solution of alkali on autoclaving, but appeared to destroy or neutralize substances that in some tests interfered with action of indicator.—*R. E. Thompson.*

Steam-Turbine-Driven Centrifugals. V. DINTR. Z. Zuckerind. cechoslov. Rep. **47**: 444–7, 1923. From Chem. Abst., **17**: 3391, October 20, 1923. Tests were made on experimental model from Breitfield, Danek and Co. Making

certain assumptions as to efficiency of other power devices, it is calculated that mechanical efficiency of belt-driven centrifugals is 72 per cent; electrically driven, 53 per cent; water-driven (water supplied by steam pump) 45 per cent, and water-driven using electrically operated centrifugal pumps, 23 per cent. Steam-turbine-driven machine has mechanical efficiency of 97 per cent, and because of simplicity of construction it is probably superior to other types.—*R. E. Thompson.*

Chemical Analysis of Water from Caravan Wells in Arabia. GEORGIADES. J. pharm. chim. **27**: 497-502, 1923. From Chem. Abst., **17**: 3393, October 20, 1923. Data on 7 waters of ill-defined origin.—*R. E. Thompson.*

Catalytic Action of Colloids in Corrosion. JOS. K. WOOD. Chem. Met. Eng., **29**: 188-92, 1923. From Chem. Abst. **17**: 3313, October 20, 1923. Discussion of colloidal theory of corrosion proposed by Friend (C. A. **15**: 3013).—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Soils and Natural Waters in Relation to Animal Distribution. W. R. G. ATKINS. Rept. Brit. Assoc. Advancement Sci., 1922, 373. From Chem. Abst., **17**: 3345, October 20, 1923. Close connection exists between distribution of plants and soil reaction, and furthermore many animals (especially insects) are related to specific plants. These facts are correlated, with aid of several examples (mosquito larvae, etc.), to show that direct relation exists between distribution of certain animal life and soil reaction.—*R. E. Thompson.*

Therapy and Prophylaxis in the Control of Goiter. J. WAGNER-JAUREGG. Wiener klin. Wochschr., **36**: 139-42, 1923. From Chem. Abst., **17**: 3371, October 20, 1923. Discussion of recent attempts to control goiter by various means of iodine administration, particularly in Switzerland.—*R. E. Thompson.*

The Therapeutic Use of Iodine in Goiter. N. JAGIC and G. SPENGLER. Wiener klin. Wochschr., **36**: 264-5, 1923. From Chem. Abst., **17**: 3371, October 20, 1923. Favorable clinical results of iodine treatment of goiter and various forms of Basedow's disease reported.—*R. E. Thompson.*

Acid- and Rust-Proof Materials for Chemical Works. REX FURNESS. Chem. Age (London) **9**: 198-200, 1923. From Chem. Abst. **17**: 3391, October 20, 1923. Description of more important acid- and rust-proof materials together with discussion of chemical properties demanded.—*R. E. Thompson.*

Presence of Barium and Strontium in Natural Brines. A. G. FRANCIS. Analyst, **48**: 315-20, 1923. From Chem. Abst., **17**: 3309, October 20, 1923. Barium and strontium sometimes in amounts of 10 p.p.m. each have been detected in English and Scottish brines obtained in boring for oil. Method of analysis consisted in removing iron and aluminium with ammonium hydroxide, precipitating barium as barium sulfate after removal of strontium and calcium as oxalates, conversion of oxalates to oxides by ignition and to nitrates by

treatment with nitric acid, and treatment of anhydrous nitrates with alcohol. Presence of barium and strontium is accounted for as follows: Water charged with carbon dioxide falls upon igneous rocks containing feldspar, hyalophanes and micas and some alkaline earth passes into solution as bicarbonate. Water subsequently percolates through rock or stratum containing zeolites or kindred minerals which retain alkaline earth like permutite filter; then when brine comes in contact with zeolite there is exchange of alkaline earth of sodium.—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Natural Waters and Some Etching Reagents in Relation to Action on Metals. W. R. G. Atkins. Trans. Faraday Soc. (advance proof), 1922. From Chem. Abst., **17**: 3313, October 20, 1923. H-ion concentration of natural waters varies between pH 6 and 8.3 unless more acid as result of oxidation of sulfur. Solutions of ferrous salts become more acid on standing, ferric hydroxide being precipitated. Ferric hydroxide is completely precipitated before ferrous hydroxide as solution is made progressively more alkaline and latter is not completely precipitated at pH 7.1. Thus, trace of acid suffices to attack iron, and hydroxide produced by hydrolysis is oxidized and precipitated, upsetting equilibrium and regenerating the acid.—*R. E. Thompson.*

Corrosion of Non-Ferrous Metals. W. Fraenkel. Z. Metallkunde, **15**: 161–3, 1923; cf. C. A. **17**; 2554. From Chem. Abst. **17**: 3313, October 20, 1923.—*R. E. Thompson.*

Effect of Alkali on Portland Cement. K. Steik. Wyoming Agr. Expt. Sta. Expt. Circ., **16**: 4 pp., 1922. From Chem. Abst., **17**: 3239, October 10, 1923. Of salts which may be present in alkali, magnesum chloride has greatest disintegrating effect upon concrete, followed by sodium sulfate and magnesium sulfate. Sodium chloride increases and sodium carbonate decreases the harmful effects of sulfates. Sodium chloride when present alone has almost no effect. Mortars containing small quantities of cement disintegrate in less time. Age of cement before it comes in contact with solutions of alkali does not seem to have great effect on rate of disintegration.—*R. E. Thompson.*

The Mechanism of Corrosion. John Johnston. Ind. Eng. Chem., **15**: 904–5, 1923. From Chem. Abst., **17**: 3312, October 20, 1923. In study of corrosion proper emphasis has not been placed on influence of effects at surface of metal. Study of equilibrium in systems at surface of corroding metal and of electrical resistance and capacity of protective films should yield information that would help in understanding of problem.—*R. E. Thompson.*

The Corrosion of Iron in the Presence of Iron Sulfide. Robert Stumper. Compt. rend. **176**: 1316–7, 1923. From Chem. Abst. **17**: 3313, October 20, 1923. Corrosion of iron in tap and chlorinated mineral waters at 17°C., was accelerated 95 and 68 per cent respectively by direct contact with iron sulfide. In 1 per cent sodium chloride direct contact accelerated corrosion 230 per cent and indirect contact by means of iron wire induced strong galvanic action and

increased corrosion 470 per cent. Phenomenon is clearly electrical.—*R. E. Thompson.*

Base Exchange in Ground Water by Silicates as Illustrated in Montana. B. COLEMAN RENICK. U. S. Geol. Survey Water Supply Paper 520-D: pp. 53–72, December 15, 1924. A study of analyses of water from well s of different depths in certain formations in Rosebud County, Montana. Waters from wells less than 125 feet deep are hard and those from deeper waters are soft. It is believed that the soft waters are derived from the harder waters by a process of natural softening which occurs within 125 feet of surface as they percolate downward, exchange of bases being largely brought about by the mineral leverrierite, a hydrous silicate of aluminum. Other hydrated silicates, such as kaolin, feldspars, and mica may also be effective.—*David G. Thompson.*

A Study of Coastal Ground Water with Special Reference to Connecticut. JOHN S. BROWN. U. S. Geol. Survey Water Supply Paper 537: 1925, pp. 97, 7 pl. and 20 figs. Primarily a study of contamination of fresh-water-bearing beds by salt water along sea coasts. Discusses hydraulic principles involved in contamination of wells, as shown by experience in Long Island and European well fields. Important facts are: (1) that zone of diffusion between fresh and salt water is narrow, (2) that under heavy pumping the change from fresh to strong salt water may take place in a short time, and (3) that once contamination has occurred it is difficult if not impossible to eradicate it. New data given as to contamination of wells along Connecticut coast. Contains bibliography, including several important foreign publications, of literature of salt water problem, with quotations of some of most pertinent material.—*David G. Thompson.*

The Salton Sea Region, California—A Geographic, Geologic, and Hydrologic Reconnaissance with a Guide to Desert Watering Places. JOHN S. BROWN. U. S. Geol. Survey Water Supply Paper 467: 292 pp. 1923. Gives special attention to water supplies in desert parts of Riverside and Imperial counties with data on ground water in many parts of the region, including analyses. Discusses vegetation as an indicator of ground water.—*David G. Thompson.*

Preliminary Report on the Geology and Water Resources of the Mud Lake Basin, Idaho. H. T. STEARNS and L. L. BRYAN. U. S. Geol. Survey Water Supply Paper 560-D: pp. 87–132, October 20, 1925. Gives an inventory of surface and ground water supply of a region underlain by lava beds. In 1908 Mud Lake covered about 2500 acres. By 1914 lake had risen 5 feet and area increased to 14,200 acres. This increase is believed to be due to underground movement of surplus water from liberal subirrigation on Egin Bench, 25 miles distant, as shown by contours of water table. Map of water table contours also shows ground water around Mud Lake to be perched 250 to 275 feet above a lower water table. About 162,000 acre-feet appeared at surface in Mud Lake and vicinity from April 1, 1921, to March 31, 1922. Of this amount about 96,000 acre-feet came from underground sources, 47,000 acre-feet from Camas Creek and 19,000 acre-feet fell as rain or snow. Measurements of

evaporation from land and floating pans and from a pan filled with tules indicated discharge by evaporation and plant growth of 41,000 acre-feet. Evaporation from floating pan was about 75 per cent of that from land pan and from tule-filled pan in growing season much greater than from land pan.—*David G. Thompson.*

Information for Applicants for Construction, Alteration or Repair of Dams. New Jersey Dept. of Conservation and Development, 9 pp. 7 plates. Gives the New Jersey law relating to erection of dams and information, including specimen maps and cross sections, to guide applicants in submitting plans.—*David G. Thompson.*

Biennial Report of the Division of Water Rights, California Department of Public Works. 179 pp., November 1, 1924. Besides usual administrative report, including review of number of decisions on water rights, report contains brief special appendices summarizing investigations on salinity of river water in Sacramento-San Joaquin delta, return waters reaching these rivers, and duty of water in the Great Central Valley. In 1924, although flow of Sacramento River did not get as low as minimum of 1920, the driest previous year, salinity reached higher proportions than in 1920. This was because the low river flows were reached much earlier in 1924 than in 1920.—*David G. Thompson.*

Some Geochemical Relations of Ground Water and Associated Natural Gas in the Lance Formation, Montana. B. Coleman Renick. Jour. of Geology, 32: 8, 668–684, November–December, 1924. Discusses analyses of water and gas from ten artesian wells in Central Montana. Gases from all ten waters contain 30 per cent, or more, of nitrogen and two contained 95 and 96 per cent respectively. These two contained no methane which was present in remaining samples, being derived from coal and disseminated carbonaceous material in the formations. Reactions between various components of gases and waters are discussed.—*David G. Thompson.*

Ground Water in Musselshell and Golden Valley Counties, Montana. A. J. Ellis and O. E. Meinzer. U. S. Geological Survey Water Supply Paper 518: 1924, pp. 90, 5 pl. and 11 figs. Describes geology and occurrence of ground water in counties named, with analyses of water from a number of wells and springs. Ground water is used principally for domestic and farm purposes. In parts of region the water yielded is either very scanty or of poor quality, so that cisterns must be used.—*David G. Thompson.*

Gaseous Content of Ground Waters as an Aid to the Petroleum and Natural Gas Prospector. G. W. Jones, W. P. Yant, and E. P. Buxton. U. S. Bur. Mines, Serial No. 2553, 15 pp. mimeographed, December, 1923. Analyses of gases dissolved in ground water may be used to show whether oil or gas sands are present in region through which waters passed. This paper describes apparatus and methods used for determining dissolved hydrocarbon vapors in water, gives results of analyses of gas in waters from different localities, and

discusses significance of these with reference to indications of oil and gas.—*David G. Thompson.*

Chemical Character of Ground Waters of the Northern Great Plains. H. B. RIFFENBURG. U. S. Geol. Survey Water Supply Paper. **560-B**: pp. 31–52, April 2, 1925. Discussion of chemical character of waters in sedimentary formations of northern Great Plains, and of differences noted in waters (1) from different formations, (2) from same formation in different localities, and (3) from different horizons in a formation. It is concluded that waters of meteoric origin have generally replaced original waters of sedimentation. Besides analyses of waters from different formations, report contains original data on analyses of rain water and on effect of rock samples in changing natural waters which were allowed to percolate through them.—*David G. Thompson.*

Construction of Wood Stave Pipe Line. J. B. HOLDCROFT. Can. Eng., **49**: 1, July, 1925. Details of construction of longest continuous wood stave pipe in Eastern Canada for supplying fresh water. Total length 29,891 feet; diameter 24 inches; creosoted stock employed where buried. Using the formula of Williams and Hazen with c = 125 and checking against recorded flow through venturi meter, figured discharge was just over 2 per cent greater than actual. Record speed construction in Canada was established, 800 feet having been laid in one ten hour day.—*N. J. Howard.*

Organization of Physical Testing Laboratory. Bulletin Topographical survey of Canada. Can. Eng., **49**: 3, July, 1925. Topographical survey of Canada has well equipped laboratory for testing, adjusting, and maintaining standards. Functions of laboratory, importance of work, and description of equipment in the various sections are dealt with.—*N. J. Howard.*

London Waterworks Show Surplus. Extract report of E. V. BUCHANAN, Public Utilities Commission, London, Ont.; Can. Eng., **49**: 3, July, 1925. Report shows increase in metered residential, industrial, and commercial rates, including hospitals. Unmetered residential rates have dropped owing to fact that few are left unmetered. Results justify plan of metering and exemplify that "when consumer is paying for what he is using, there is a general desire for conservation."—*N. J. Howard.*

Metering of Water Services. Can. Eng., **49**: 3, July, 1925. Reductions in per capita consumption follow metering of water. Buffalo reported 47 per cent, London, Ont., 33 per cent, Cleveland, 46 per cent, and section of Baltimore, 49 per cent.—*N. J. Howard.*

Salt Velocity Method of Water Measurement. C. M. ALLEN and E. A. TAYLOR. Can. Eng., **49**: 5, August, 1925. Illustrated article on theory and development of new method of measuring water. Salt solution is introduced near upper end of conduit, and passage of solution by one or more pairs of electrodes, at other points in conduit, is recorded graphically by electrical recording instruments. Passage of salt solution between two points is timed,

and volume of penstock between same points is accurately determined. Discharge in cubic feet per second equals volume so found in cubic feet divided by time in seconds. Authors believe this method to be correct in theory and practice, and that in a few years its simplicity, accuracy, and other advantages will make it an accepted standard method of water measurement.—*N. J. Howard.*

Review of Sanitary Surveys in Ontario. F. A. DALLYN. Can. Eng., **49**: 10, September, 1925. Extract annual report Ontario Provincial Board of Health, 1924. Prior to 1913 only 7 water purification plants existed in Province. This has increased in 1924 to 41 purification plants and 96 chlorine installations. Typhoid fever mortality per 100,000 of population reduced from 31.5 in 1910 to 2.5 in 1924. Figures are given as to expenditures involved in sewage disposal and water purification in a nine year period. Provincial experimental station and laboratory used for instruction and research work and considerable number of valuable publications have been made.—*N. J. Howard.*

Ohio Sanitary Code of the Department of Health of Ohio. Ohio's Health, **16**: 2, 49. Contains 235 regulations adopted by the Public Health Council, August 20, 1925. Code includes regulations concerning water and ice supplies provided by common carriers, and water supplies for railway construction camps and state park sanitary districts. It also provides for submission and approval of plans for water supply, sewerage, industrial wastes, etc.—*G. C. Houser.*

New Regulations for Water and Sewerage Projects. Anon. Public Health News (New Jersey Dept. of Health), **10**: 10, 235, September, 1925. Rules concerning submission of data covering water and sewerage projects to be installed in New Jersey were adopted by State Dept. of Health on August 11, 1925. These rules are a revision of those adopted in 1913. Specific requirements for water treatment plants are concerned with slow sand filters, rapid sand filters, and sterilization units.—*G. C. Houser.*

Résumé of the Goiter Situation. L. C. SCOTT. Quarterly Bulletin, Louisiana State Board of Health, **16**: 4, 227, December, 1925. Discusses an account of epidemicity of goiter within confines of United States, written by McClendon and Williams. They have attempted to show that certain regions in which goiter prevails extensively also have a water supply with low iodin content. Prevention of goiter by iodizing the drinking water is also discussed. *G. C. Houser.*

Amendments to State Sanitary Code. Health News (N. Y. State Dept. of Health), **2**: 47, 185, November 23, 1925. At meeting of New York Public Health Council, held November 12, 1925, chapter VII of Sanitary Code was amended by adding thereto three new regulations, dealing with following subjects: (1) Certain cross-connections between water supplies not permitted. (2) Permissible arrangements where dual supplies are used. (3) Non-potable water in industrial plants to be rendered unavilable for drinking.—*G. C. Houser.*

Typhoid Outbreak Follows "Intestinal Flu." Anon. Health News (N. Y. State Dept. of Health), 3: 3, 12, January 18, 1926. It has been noted in past that water-borne outbreaks of typhoid fever were frequently preceded by outbreaks of diarrhea. This is one of the principal reasons why a regulation of the State Sanitary Code was adopted, prescribing that an unusual prevalence of diarrhea shall be recorded immediately by local health officer to State Department of Health by telegraph or telephone.—*G. C. Houser.*

Safe Water for the Highways. Anon. Public Health (Mich. Dept. of Health), 13: 11, 306, November, 1925. Plan for protection of Michigan's roadside water supplies was put in operation in July, 1925. Three sheet iron signs were prepared. One large sign reads: "Caution—Drink Only Water Approved by Mich. Dept. of Health." This sign serves as introduction to the smaller "safe" and "not safe" signs to be posted at actual sources of drinking water supplies.—*G. C. Houser.*

The Lake Michigan Survey. L. S. Finch. Monthly Bulletin, Indiana State Board of Health, 28: 10, 146, October, 1925. Field work of bacteriological survey being made by United States Public Health Service of waters of Lake Michigan off Indiana shores was completed during latter part of October. This work is part of a more comprehensive survey, which may be outlined as follows: (1) Sanitary survey of drainage area of Calumet River; (2) Bacteriological study of waters of Lake Michigan and of all public water supplies taken from it; (3) Collection and analysis of available data relative to influence of these water supplies on the public health.—*G. C. Houser.*

Financing Main Pipe Extensions by the Assessment Method. C. M. Saville. Jour. New Eng. Water Works Assoc., 39: 3, 185, September, 1925. Cost of laying pipe mains at Hartford (Conn.) is assessed against property on thoroughfare in which pipe is laid. Approximately one-third of total cost is borne by city, including exemptions, street intersections, oversize pipe, and connections. Discussion is included.—*W. U. Gallaher.*

Period of Storage and Micro-organisms in Reservoirs. R. S. Weston. Jour. New Eng. Water Works Assoc., 39: 3, 225, September, 1925. In general, in uplands of northeastern U. S., reservoirs suffer from microscopic organisms in inverse proportion to storage ratio (capacity divided by mean annual runoff). Surface waters are best which are gathered quickly and stored for a long period.—*W. U. Gallaher.*

A Score System for Grading Water Supplies According to Sanitary Conditions. E. S. Chase. Jour. New Eng. Water Works Assoc., 39: 3, 229, September, 1925. Perfect score of one hundred divided between three main heads, viz.—pollution hazards, 50; protective measures, 20; and quality conditions, 30. Scoring of each part depends on source of supply. Discussion follows.—*W. U Gallaher.*

Pumps Need Constant Watching. Power Plant Engineering, 80: 1, 74, January 1, 1926. Valves, packings, and bearings are principal problems in

pump maintenance. Rules for operation and care of both centrifugal and reciprocating pumps are outlined.—*W. U. Gallaher.*

Feed Water Systems. Power Plant Engineering, **80**: 1, 45, January 1, 1926. Review of methods for purification of boiler feed water. Includes filtration, preheating, softening by hot and cold lime—soda processes and by zeolite process, evaporation, deaëration, deactivation, and internal treatment by compounds, etc. A recent method consists in continuously withdrawing, filtering, and returning a portion of the boiler water. Acid is added in some plants to reduce causticity of zeolite-softened water.—*W. U. Gallaher.*

Lake Erie Water Purified for Monroe, Mich. Anon. Power Plant Engineering, **29**: 16, 828. August 15, 1925. This city of 14,000 has replaced its original pumping station by a low-lift station taking water from Lake Erie and pumping it three and one-half miles further to filtration plant. An additional crib has been constructed to alleviate trouble from needle ice. Filtration plant consists of coagulation basin with four independent compartments, each of which can be removed from service, four 1-m.g.d. filter units, and 3-mg. covered storage reservoir. First runnings from filters are stored and used later for filter-washing. Plant uses dry feed alum machines and disinfects with liquid chlorine. Dosage of alum varies from 0.7 to 4 grains per gallon and of chlorine from two to six pounds per million gallons. Two motor driven, single-stage, centrifugals are arranged to pump either wash water for filters, or waste to river. Two crank and fly-wheel pumping units, of 3- and 5-m.g.d. capacity, respectively, deliver water to mains. As auxiliary to these a 2-m.g.d. centrifugal has been installed. Uniflow engine direct connected to alternator furnishes power to electrically driven units. Boilers and their equipment are described.—*W. U. Gallaher.*

The Wheeling, West Virginia, Filtration Plant and Some Operating Results. J. F. Laboon. Jour. New Eng. Water Works Assoc., **39**: 4, 291, December, 1925. Wheeling had suffered for a long time from effects of impure water. Many plans for improvement had been recommended and two bond issues defeated. In 1922, due to extensive publicity campaign for pure water, bond issue passed. Water works improvements include filtration plant, pumping station, intake works, many large mains with cross connections, 5-m.g. reservoir, and purchase of four private water plants. Water consumption was at the rate of 400 gallons per capita per day: due to metering it has been lowered as follows:—1923, 17.3 m.g.d.; 1924, 15 m.g.d.; first three months 1925, 12 m.g.d. Predicted that with 100 per cent metering it will be 12 m.g.d. Source of supply is the heavily polluted Ohio River. Filtration plant has capacity of 20 m.g.d. and can be adapted for softening. Includes 850,000-gallon grit chamber, 415,000-gallon mixing chamber, two settling basins with combined capacity of three and one-third million gallons, ten 2-m.g.d filters, and 570,000-gallon clear water reservoir. Water may be by-passed around either grit or mixing chamber or both. Mixing chamber has five stationary concrete baffles and five adjustable wooden ones. Settling basins may be operated in series, in parallel, or separately. Filters have concrete false bottom instead of pipe lateral underdrains.

Master control for setting all controls is provided in addition to master rate-of-flow gage and samplers. Wash water is stored in 125,000-gallon steel tank automatically kept full. Plant has many conveniences for unloading chemicals. Lime and iron, or alum, are fed by five dry feed machines. Water injector is used to clean chemical line. Since February, 1925, when plant was put in operation, bacterial removal, 37°C., has averaged 84 per cent. Alkalinity of water is low and is kept at 10 p.p.m. Curves are given showing fluctuations in hardness, alkalinity, carbonic acid, and turbidity; dosage of iron, lime, and alum; length of filter runs; and percentage wash water used. Total cost of filtering $6.38 per million gallons. Total cost, including pumpage, but excluding fixed charges, $22.98. Cost of plant $604,940: of entire system, $1,763, 460.—*W. U. Gallaher.*

Tastes in the Water Supply of Marquette, Mich., Due to Phenol Wastes. PAUL HANSEN. Jour. New Eng. Water Works Assoc., **39**: 4, 320, December, 1925. History dating from 1901 is given of the occurrences and consequent investigations of tastes in water supply caused by dumping of phenol wastes in vicinity of intake. Following are suggested as solutions to problem:—(1) establishment of intake beyond reach of wastes; (2) diversion of wastes beyond reach of present intake; (3) treatment of wastes at plant; (4) treatment of water supply to eliminate tastes; and (5) mixing wastes with city sewage. Taste-producing waste can be carried a greater distance by low than by high velocity wind. Depth of circulation due to temperature is about two hundred feet; so that within practicable limits, at no place in Marquette Bay could intake avoid wastes. Pumping wastes to Middle Bay would meet with objections from that locality. Experimental treatment reduced wastes about 50 per cent; mixing with sewage, 75 per cent. Partial treatment of wastes and subsequent mixing with city sewage seems most feasible plan.—*W. U. Gallaher.*

Moving a 100,000-Gallon Steel Tank a Quarter of a Mile. J. D. KEILEY. Railway Engineering and Maintenance, **21**: 9, 343, 1925. A 100,000-gallon elevated steel tank, 70 ft. high, was moved one-quarter mile at the C. &. O. Railway Russell Terminal and placed on new foundation by local forces. Detailed description of the supports and method of jacking and cribbing is given.—*R. C. Bardwell.*

Railroad Reservoir in Kansas Provides Large Ice Harvest. Anon. Railway Engineering and Maintenance, **21**: 9, 358, 1925. 4,975 tons of ice were secured, loaded, and stored from 200,000,000 gallon reservoir of Missouri Pacific Railway at Hoisington, Kansas, effecting net saving of $8,691.00.—*R. C. Bardwell.*

Building a Large Intake Pipe Line in Lake Michigan. C. R. KNOWLES. Railway Engineering and Maintenance, **21**: 12, 488, 1925. New line is 24-inch c. i. pipe, 650 feet long, with flexible ball joint every 48 feet from suction well to lake intake. Pipe was put together and loaded in 48-foot sections on barge, connected to previous ball joint, and then lowered with derrick. Inspection and leveling were handled by diver. Pipe was increased to 30-inch with galvanized screen where it passed through rock filled breakwater. Photographs and plans are shown.—*R. C. Bardwell.*

Should Hydrants Be Packed Without Sawdust? E. M. GRIME and H. P. BLAKE. Railway Engineering and Maintenance, **21**: 12, 501, 1925. Sawdust has been found to cause lead corrosion when moist. Full ground cover with proper drainage from base of hydrant pit with dead air space and false cover is recommended.—*R. C. Bardwell.*

Concrete Tanks Like New After Twenty Years' Use. Anon. Railway Engineering and Maintenance, **21**: 9, 356, 1925. On Atlantic and West Point, and Western Railway of Alabama, respectively, 50,000-gallon reinforced concrete water tanks at Hogansville, Ga., and Natasulga, Ala., have been in continuous railway water service since 1905. The interesting feature is lightness of design. Tanks are cylindrical, 29 feet dia. by 12 feet high, on 13 feet high, 13 concrete post frame. Floor is 5 inches thick, side wall, 4 inches, and dome roof 2 inches. Reinforcing is $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{5}{16}$ bars. Mix is 1:2:4. Three $\frac{1}{4}$-inch coats of 1:1 mortar were applied to interior walls and floor. No other water proofing was used. Tanks are still in first class condition.—*R. C. Bardwell.*

New Lackawanna Water Station Shows Low Operating Cost. H. W. MACHEMER. Railway Review, **77**: 10, 354, and Railway Engineering and Maintenance, **21**: 10, 377, 1925. The D. L. & W. R. R., recently rebuilt water station at Groveland, N. Y. Two 150 h.p. locomotive type boilers and steam plunger pumps were replaced by two 50 h.p. and one 15 h.p., Type "Y" crude oil engines, and 6-inch single stage centrifugal pumps. Change from steam to fuel oil effected large operating saving. Lime and soda ash treatment facilities consist of intermittent plant with air agitation and subsequent filtration through pressure filters. Three 85,000-gallon flat bottom steel tanks are used for treatment. Four hour sedimentation period is provided.—*R. C. Bardwell.*

Missouri-Kansas-Texas Improves Water Supplies. J. H. DAVIDSON. Railway Age, **79**: 10, 445, 1925; Railway Engineering and Maintenance, **21**: 8, 309, 1925. Comprehensive program for improvement of water supply quality on M. K. & T. R. R. system has effected marked improvement in locomotive performance. Prior to 1916 various boiler compounds were used with inconsistent results. At close of 1923, 35 complete lime and soda ash softeners and 52 soda ash plants were in service, at 60 per cent of water stations, and 65 per cent of water used was treated. Complete softeners are of continuous type with various feeding arrangements. Reduction in boiler failures has amounted to between 85 and 97 per cent. Saving in fuel varies from 6 to 14 per cent for different classes of service. Improved water conditions have helped to make possible increase in continuous locomotive run of from 275 to 869 miles. Photographs, diagram, and charts are included.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Water Softening Developments—Rock Island Lines. P. M. LABACH. American Railway Engineering Association Bulletin, **27**: 277–87, 1925. Detailed laboratory experiments and results from water softening plants at Council Bluffs, Ia., and Estherville, Ia., indicate that less material can be used with better results and greater reduction in harness if Na_3AlO_3 is added

to the water separately from the lime and soda ash.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

A Thousand Dollars for the Best Answer. CHARLES DILLON. Railway Review, **77**: 23, 833, 1925. Pitting and corrosion is causing acute trouble in Railway locomotive boilers. Railway Review is offering cash prize for best solution offered, on or before March 31st, 1926.—*R. C. Bardwell.* (*Courtesy Chem Abst.*)

Committee Report on Feed Water Heaters. Anon. Railway Review, **77**: 23, 853, 1925. Report presents discussion of open and closed types, exhaust steam injectors, and direct methods for steaming locomotives. Proportional feed of chestnut bark extract is recommended for reducing scale troubles in closed system. Non-corrosive coating is suggested for protecting steel parts from pitting. A trouble common to both types is scale formation found at opening to boiler beyond the check valve. This should be cleaned every 90 days.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Treated Water Increases Locomotive Efficiency. R. C. BARDWELL. Railway Review, **77**: 18, 669. Railway Age, **79**: 17, 769, 1925. General paper on methods of water softening as applied to Railway use. Estimated figures are given on consumption and cost data.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Providing a Railroad's Water Supply. R. C. BARDWELL. Railway Age, **79**: 11, 517, and 20, 885, 1925. Increasing attention given to water quality and pumping equipment are reducing railway transportation costs. Various features of treating and pumping equipment are discussed.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

A Study of the Effects of Anions upon the Properties of "Alum Floc." L. B. MILLER. Public Health Reports, **40**: 8, 351, February 20, 1925. Importance of negative ion content of solution in relation to some of chemical and physical properties of alum floc is established. Bearing upon water purification by alum process is discussed. In this connection the effect of several negative ions upon form of electrometric titration curve is demonstrated. Relation of hydrion concentration and anion content of solution to formation of aluminum precipitate is determined for several anions. Dependence of physical state of insoluble aluminum compounds formed—their existence in colloidal suspension or as coagulated precipitate—upon anions present is emphasized. Lack of agreement in literature upon region of hydrion concentration in which coagulation of alum takes place is explained as partially due to negative ion content of solutions in question and to presence of colloidal material such as silicic acid or organic matter. Relation of "hydrion zone of coagulation" to "hydrion zone of rapid coagulation" for aluminum sulphate and aluminum chloride is determined. For aluminum sulphate it is demonstrated that "hydrion zone of rapid coagulation" tends to shift towards more acid portion of "hydrion zone of coagulation." A few possible applications of the principles

discussed in this paper are pointed out, and in particular the coördinate importance of the aluminum ion and of the sulphate ion for current water works practice is emphasized. A bibliography is appended.—*Aug. G. Nolte.*

Report of Advisory Committee on Standards for Drinking Water Supplied to the Public by Common Carriers in Interstate Commerce. Public Health Reports, **40**: 15, 693, April 10, 1925. Committee composed of representatives from government departments and scientific associations and of eminent sanitarians. Recommendations submitted apply only to a special case, i.e., of formulating definite specifications which may be used by Public Health Service in administrative action which it is required to take upon supplies of drinking water offered by common carriers for use of passengers carried in interstate traffic. Committee has taken the better class of water supplies of municipalities as its standard of comparison with respect to safety. Proposed standards recommend requirements, (1) As to source and protection; (2) As to bacteriological quality and (3) As to physical and chemical characteristics. As regards first requirement, sanitary survey of the water supply should be made by a competent person; brief general description of water supply should be submitted and brief summary of pertinent facts relating to sanitary condition of supply, as revealed by field survey, should be submitted. As regards second requirement, committee have proposed omission of plate counts and inclusion only of quantitative estimation of organisms of B. coli group by applying specific tests to multiple portions of measured volume. As regards third requirement, committee have defined a satisfactory water as one that is clear, colorless, odorless, pleasant to the taste, free from toxic salts, free from an excessive amount of soluble mineral substances and free from an excessive amount of chemicals employed in treatment. Maximum allowable values are given for physical and chemical characteristics of acceptable water supplies.—*Aug. G. Nolte.*

Highway Signs to Show City has Approved Water Supply. Public Health Reports, **40**: 16, 787, April 17, 1925. Minnesota State Board of Health posts signs on highways approaching municipalities having water supplies approved by State Board of Health. Supplies investigated once each year. Signs removed if at any time water supply is found unsatisfactory.—*Aug. G. Nolte.*

The Supplying of Drinking Water to Vessels in the United States. J. I. CONNOLLY. Public Health Reports, **40**: 21, 1042, May 22, 1925. In this paper are outlined briefly some of water supply problems of American vessels in coastwise, river, and Great Lakes services. Two distinct divisions of the vessel water supply problem are recognized: (1) Where water is obtained from sources ashore, and (2) where it is taken from overboard. Given a satisfactory source ashore (a safe water), question of getting water aboard in sanitary manner and of storing and distributing it properly is of vital importance. Water taken on vessels from overboard is delivered through seacocks, located below water line. Methods of treating "overboard" water to be used for drinking purposes are distillation, treatment by ultra-violet rays, by ozone, and by hypochlorites. Filtration as preliminary treatment is required for

efficient disinfection in all cases except the first, since raw water may at times contain considerable organic matter in suspension.—*Aug. G. Nolte.*

Some Properties of Iron Compounds and Their Relation to Water Clarification. L. B. MILLER. Public Health Reports, **40**: 27, 1413, July 3, 1925. In summary of this paper it is stated that,—"(1) The electrometric titration curve of ferrous sulphate by alkali has been determined; (2) The composition of the precipitate from ferrous sulphate at varying hydrogen ion concentrations has been determined in a nitrogen atmosphere; (3) The titration curves of ferric alum and ferric chloride by alkali have been made, using colorimetric methods; (4) The composition of the precipitate from ferric alum at varying hydrogen ion concentrations has been determined. The precipitate from ferric chloride did not lend itself to this type of analysis; (5) The ranges of hydrogen ion concentration over which precipitation occurs with ferric alum and ferric chloride has been determined; (6) The relation of these experimental facts to water clarification by copperas has been discussed. The importance of these data as a basis for a further study of principles has been pointed out."—*Aug. G. Nolte.*

Notes on the Clarification of Colored Waters. L. B. MILLER. Public Health Reports, **40**: 28, 1472, July 10, 1925. A number of samples of water containing "color" of the humic acid type from several sources were studied in some detail by three different methods of experimentation; namely, (1) by dialysis, (2) by cataphoresis, and (3) by the study of the effect of various chemical reagents upon the stability of the "color" in solution. In every case investigated the color proved to be present as negatively charged colloid. The coagulation and removal of the "color" (formation of the "color floc") by electrolytes was shown to be effected by the cation. With respect to the clarification of colored waters by alum, it was suggested that the clarification was due to aluminum ion and that "alum floc" which is effective in the clarification of turbid waters, had an unimportant rôle in the removal of "colors" of this type. The conditions most favorable for color removal by alum were discussed. Possible limitations in the application of the principle were pointed out.—*Aug. G. Nolte.*

Dual Water System Responsible for Typhoid Case. Public Health Reports, **40**: 34, 1763, August 21, 1925. Case occurred in an industrial plant in Niagara Falls. In addition to municipal water supply connected with drinking fountains, company had private supply obtained directly from Niagara River. This water was filtered but not chlorinated. Water faucets for wash basins in rest rooms were found connected with this supply. As no warning notices had been posted, it was stated to have been common practice for employees to drink this water. Analysis showed water to be badly polluted. Warning notices then posted.—*Aug. G. Nolte.*

Stream Pollution by Wastes from By-Product Coke Ovens. R. D. LEITCH. Public Health Reports, **40**: 39, 2021, September 25, 1925. General review of subject is given. Effect, extent, and sources of pollution as well as methods of disposal and cost of systems are discussed.—*Aug. G. Nolte.*

Year's Progress in Power Field Shows Many Marked Advances. Power, 63: 1, 2, January 5, 1926. Remarkable reduction in fuel consumption shown in many recent innovations in equipment and station design. Air preheating and water cooled walls prominent in furnace design. Improved metals give preference to high temperatures over high pressures. Present limitations and status of various auxiliaries, fuels and combustion, and steady growth of steam turbines are discussed. Steam engine to remain an important factor for some time to come. Much activity shown in internal-combustion engine industry and in water power development. No radical changes in electrical apparatus.—*Aug. G. Nolte.*

Wood Refuse Burned on Underfeed Stokers. C. M. GARLAND. Power, 63: 2, 46, January 12, 1926. Illustrated.—*Aug. G. Nolte.*

Why Boiler Tubes Burnt Out. GEORGE C. REINHARD. Power, 63: 2, 51, January 12, 1926. Scale removal resulted in tube failure. Various theories investigated. Conclusions drawn from investigation were that corrosion was due to external cause; that external superheating could not be responsible in view of interior condition of tubes; that oil jets were not responsible; that blistering and blowout were due to corrosive action caused by combustion and oxidation of sulfur to sulfuric acid, which corrosion, in conjunction with fusion of products of corrosion, weakened the tubes; that cause could be traced directly to sulfur content of oil. Recommendations made were reduction or elimination of sulfur in oil and frequent external cleaning of tubes.—*Aug. G. Nolte.*

Recooling Oil-Engine Jacket Water. EDGAR J. KATES. Power, 63: 2, 57, January 12, 1926. Simplest method is to expose water to air in "open cooling systems." Cooling sprays cool by dividing water into small drops, thus increasing surface exposed to air. In all cases cooling effect is accomplished mostly by evaporating part of water and thus cooling remainder. Some of heat of water is delivered directly to the air, thus cooling water by heating air. Open cooling system has one serious defect where water is hard, that is, when it contains scale forming minerals in solution. As cooling is accomplished by evaporation and as only pure water evaporates, dissolved minerals are left behind, thus causing remaining water to become more concentrated in mineral salts. When such water is heated in engine jackets, it is unable to retain all the mineral matter in solution, whereupon scale is deposited on jacket walls. Dead Sea in Asia Minor is striking example of results of continuous evaporation, as solids in solution that body of water now make up one-quarter of entire weight of water.—*Aug. G. Nolte.*

Engineering Bulletin No. 2. Maryland State Department of Health. September, 1925. **Values in the Control of Environment.** ABEL WOLMAN. 6–14. **Hygienic Aspects of the Use of Sewage Sludge for Fertilizer.** ABEL WOLMAN 15–32. **Preliminary Observations on Lime Treatment of Sewage Sludge.** T. C. SCHAETZLE. 33–42. **Studies of Sewage Treatment Plant at the Maryland House of Correction, 1920.** CHARLES R. COFF. 43–54. **A Study of the Qualities of Limestone for Use on Sewage Trickling Filters.** T. C. SCHAETZLE. 55–62.

Report on Sanitary Privy Construction and Maintenance. FRED W. CASPARI. 63–72. **Water and Sewage Construction at State Institutions.** GEORGE L. HALL. 73–86. Under provisions of the water supply and sewerage law of 1914, the Bureau of Sanitary Engineering has made water and sewerage improvements at state institutions, the total cost of which amounted to $227,496 in 1924, exclusive of engineering costs. Description of work at various institutions is given. **Garbage Incinerator for Camps.** A. P. GWYNN. 87–89. **The Occurrence of Tastes and Odors in Hyattsville Water District System after Painting Elevated Tank.** ABEL WOLMAN. 90–92. Investigation indicated the following combination of circumstances as responsible for unusual tastes and odors: use of coal-tar paint, some of whose constituents were soluble in water; placing elevated tank in service before paint hardened; use of 1 p.p.m. chlorine within tank, in addition to a dosage of 0.4 p.p.m.; low temperature of water supply. **Effect of Oil of Chenopodium on Fish Life.** T. C. SCHAETZLE. 93–102. **Effect of Chemically Treated Water on Goldfish.** A. P. GWYNN. 103–104. Study indicated that super-saturation of oxygen in water and not chemical treatment was responsible for fish mortality. Fish life is not affected seriously either by chlorine as high as 3 p.p.m. or by sulfuric acid, copper sulfate, or alum in doses higher than usually employed. **Analytical Study of the Waters of Antietam Creek.** T. C. SCHAETZLE. 105–141. **Some Problems in Industrial Wastes Treatment.** T. C. SCHAETZLE and S. T. POWELL. 142–148. Outline of problems in and around Baltimore City as presented before American Chemical Society meeting April 9, 1925. **Treatment of Wastes from Congoleum Manufacturing.** T. C. SCHAETZLE. 149–156. **Float Investigations on Susquehanna River at Havre de Grace.** A. P. GWYNN. 157-161. **Study of Sewage Pollution of Sinepuxent Bay.** ABEL WOLMAN, A. E. GOODRICH and W. N. SPRING. 162–168. **Metropolitan District Planning in Maryland.** ABEL WOLMAN. 169–178. Total population in Maryland, exclusive of Baltimore City, now under unified or metropolitan management for water supply, sewerage, storm-water drainage, and refuse disposal totals over 100,000. Method of financing provides for accumulation of funds from taxes, special assessments, and service rates. Special assessments developed on front-foot basis and provide for fixed charges. Increase in tax rate covers approximately fixed charges on cost of reservoirs, pumping plants, etc., which may be assumed to be community benefits. Service rates provide for maintenance and operation charges.—*A. W. Blohm.*

NEW BOOKS

Elementary Guide to Reinforced Concrete. LAKEMAN, ALBERT. London: Concrete Publications Ltd. Paper; 6 x 9 in.; pp. 69; 79 linecuts. 2s. Reviewed in Eng. News Rec., 95: 645, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete, Plain and Reinforced, Vol. I. TAYLOR, FREDERICK, THOMPSON, W., SANFORD E., and SMULSKI, EDWARD; with a chapter by ROBBINS, HENRY C. 4th Ed. New York: John Wiley & Sons Inc., London: Chapman & Hall,

Ltd. Cloth; 6 x 9 in.; pp. 969; 311 line cuts. $8. Reviewed in Eng. News Rec., 95: 642, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Provvista e Distribuzione di Acqua Potabile. CLAUDIO MISTRANGELO. Milan: U. Hoepli. 389 pp. L. 36. From Chem. Abst., 17: 2929, September 10, 1923.—*R. E. Thompson.*

Public Utilities and the Law. WM. M. WHERRY, JR. New York: The Writers' Publishing Co., Inc. Cloth; 5 x 8 in.; pp. 337. $3. Reviewed in Eng. News Rec., 95: 643, October 15, 1925.—*R. E. Thompson.*

Zur Bestimmung Strömender Flüssigkeitsmengen im offenen Gerinne. O. POEBING. Berlin: Julius Springer. M. 1.70. Reviewed in Wasser u. Gas, 14: 188, 1924. From Chem. Abst. 18: 1026, April 10, 1924.—*R. E. Thompson.*

Über Wasserversorgungsanlagen. F. SCHLOTTHAUER. 3rd. Ed. Munich and Berlin: R. Oldenbourg. M 3-M 4. Reviewed in Gesundh. Ing., 46: 164, 1923. From Chem. Abst. 18: 1026, April 10, 1924.—*R. E. Thompson.*

Kalender für das Gas- und Wasserfach. G. THIEM. Vol. 47. Munich and Berlin: R. Oldenbourg. Reviewed in Gesundh. Ing., 47: 30, 1924. From Chem. Abst. 18: 1046, April 10, 1924.—*R. E. Thompson.*

Analysis of Potable Waters. P. MOLLIEX. Paris: Libraire le François. 91 Bvd. St. Germain. pp. 96. F 4. From Chem. Abst., 18: 1355, May 10, 1924.—*R. E Thompson.*

The Composition of the River and Lake Waters of the United States. FRANK WIGGLESWORTH CLARK. U. S. Geol. Survey Professional Paper 135: 199 pp. 1924. This report contains several thousand analyses of some 650 different river and lake waters in the United States, with discussion of relations between waters and nature of rocks in which they originated. As was to be expected from so eminent an authority on geochemical data, a large amount of valuable information is included. Introduction considers relative value of different forms of statement of water analyses, and problems arising in interpretation of analyses. All analyses are stated in ionic form in parts per million and many in addition are also given in percentages. Under discussion of interpretation of analyses are considered such subjects as: value of analyses from different sources; source of a water—whether it is a "simple water" originating in an area of rocks of uniform lithologic character, or a "blend" or mixture of waters originating from rocks of different characters, such as are brought to a trunk stream by tributaries—; variations in composition of a river water from time to time and from place to place; relative quantities of various salts in waters; and significance of different constituents. Tables of analyses, with accompanying interpretations, are arranged by drainage basins. For many of the more important streams 30, or more, analyses covering ten-day periods for at least a year are given.—*David G. Thompson.*

En ny indikator a vattenförorening. (A New Indicator of Water Pollution. —ABSTR.) H. HUSS. Göteborg: Oscar Briscon. 31 pp. Reviewed in Gesundh. Ing., **46**: 496 (1923). From Chem. Abst., **18**: 1355, May 10, 1924.—*R. E. Thompson.*

Kalender für Gesundheitstechniker. H. RECHNAGEL. Munich and Berlin: R. Oldenbourg. Reviewed in Wasser u. Gas, **14**: 147, 1924. From Chem. Abst., **18**: 1355, May 10, 1924.—*R. E. Thompson.*

An Introduction to the Methods of Economic Statistics. WILLIAM LEONARD CRUM and ALSON CURRIE PATTON. Chicago and New York: A. W. Shaw Co. Flexible; 6 by 9 inches; pp. 493. $6. Reviewed in Eng. News-Rec., **95**: 126, January 21, 1926.—*R. E. Thompson.*

Statistical Method. HARRY JEROME. New York and London: Harper & Brothers. Cloth; 6 by 9 inches; pp. 395. $4. Reviewed in Eng. News-Rec., **96**: 126, January 21, 1926.—*R. E. Thompson.*

Elements of Business Statistics. ROBERT RIEGEL. New York and London: D. Appleton & Co. Cloth; 6 by 8 inches; pp. 549. $4. Reviewed in Eng. News-Rec., **96**: 126, January 21, 1926.—*R. E. Thompson.*

Guiding Principles of Public Service Regulation. HENRY C. SPURR. Vol. II. Rochester, N. Y.: Public Utility Reports, Inc. Cloth; 6 by 9 inches; pp. 750. $7.50. Reviewed in Eng. News-Rec., **96**: 127, January 21, 1926.—*R. E. Thompson.*

Public Health Law: A Manual of Law for Sanitarians. JAMES A. TOBEY. With foreword by CHARLES V. CHAPIN. Baltimore: Williams & Wilkins Co. Cloth; 6 by 9 inches; pp. 304, $4.50. Reviewed in Eng. News-Rec., **96**: 127, January 21, 1926.—*R. E. Thompson.*